Sky and TELESCOPE

Zodiacal light from space?

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Vol. XIII, No. 5

MARCH, 1954

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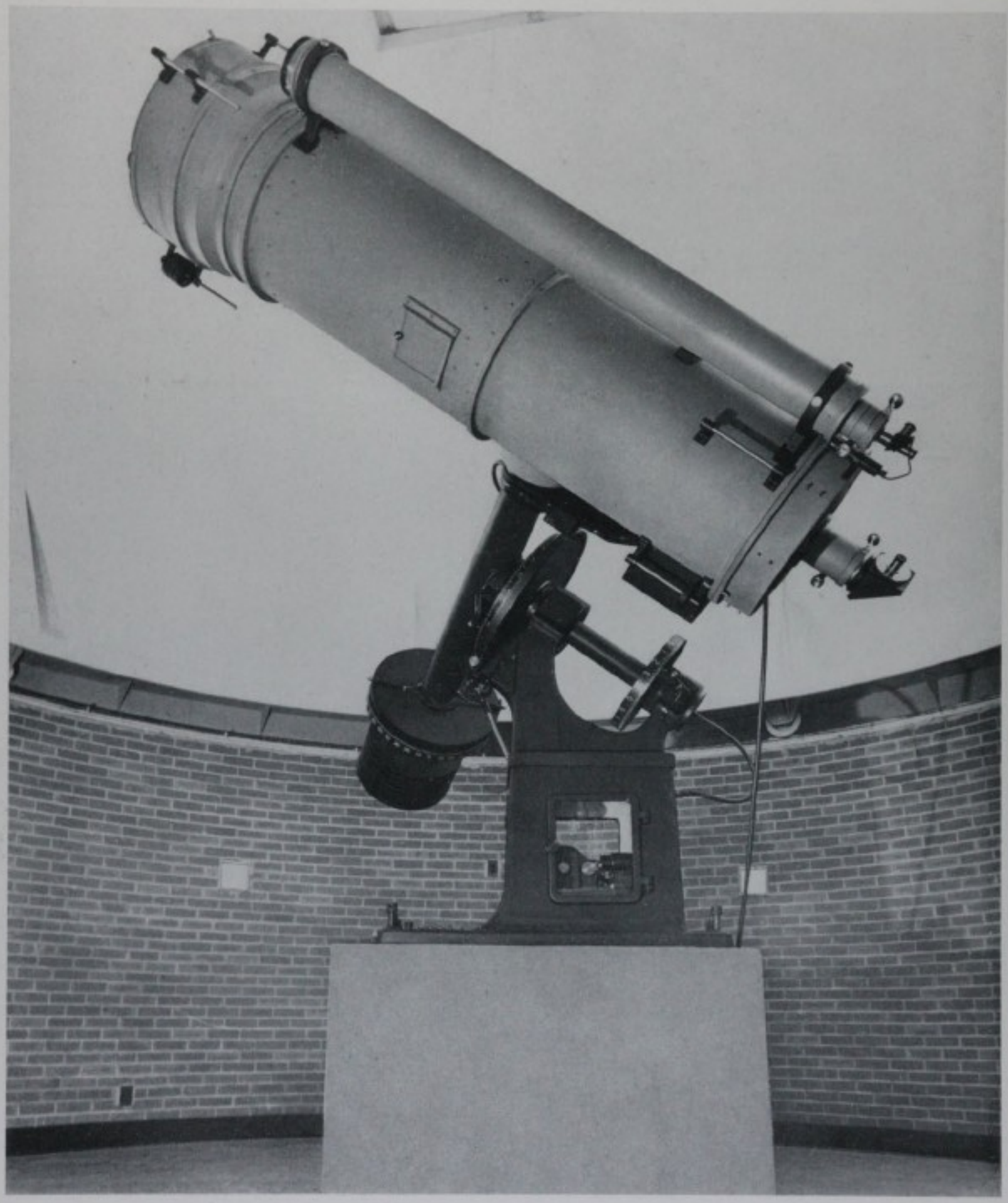

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Sky and TELESCOPE

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HARVARD OBSERVATORY DIRECTOR APPOINTED

THE PRESIDENT of Harvard University announced on January 15th the appointment of Donald H. Menzel as director of Harvard College Observatory. Dr. Menzel has been acting director of the observatory since the writer's retirement from the directorship in 1952. He also continues as ex officio chairman of the observatory council.

Dr. Menzel has had a long association with the Harvard Observatory. He first came to Cambridge as a Princeton University graduate student in 1921 and carried on at Harvard much of the research underlying his doctoral thesis, which was entitled, "A Study of Line Intensities in Stellar Spectra," and was published in 1924 as Harvard Observatory *Circular 258*.

After one-year terms of teaching at the University of Iowa and Ohio State University, he went to Lick Observatory in 1926 as assistant astronomer. His work soon turned to solar research by way of the valuable eclipse photographs that W. W. Campbell and his associates had accumulated on various eclipse expeditions. Menzel brought to the discussion of these photographs the new techniques of spectroscopic analysis that had been developed at Princeton with Prof. H. N. Russell and at Harvard by Menzel and by Cecilia Payne (Gaposchkin). Dr. Menzel's monograph on the solar chromosphere in Lick Observatory *Publications* XVII, Part 1, 1931, established his field for subsequent and present work.

Dr. Menzel was invited to join the Harvard Observatory staff in 1932, and he became a full professor in Harvard University in 1938. Continuing with the analysis of eclipse phenomena, he explored the closely related field of stellar atmospheres. Basic spectroscopic and atomic theories are closely woven into the astrophysical interpretations of the observed characteristics of the sun, stars, and nebulae. Menzel turned his studies to these associated fields of physics and became our instructor and leading investigator in theoretical astrophysics.

Dr. Donald H. Menzel, sixth director of Harvard Observatory. Photo by Walter R. Fleischer.

The total solar eclipse of 1936 gave him an opportunity to develop unique equipment and, as it turned out, to obtain further valuable material for analysis by himself and his associates. This 1936 expedition deep into Russia was under the joint auspices of Harvard and Massachusetts Institute of Technology. Menzel was the leader. He also led an expedition to Saskatchewan for the eclipse of July 9, 1945, but this was unfortunately clouded out.

Investigations begun by Menzel in 1935 eventually led to the development and construction of America's first coronagraph. This instrument, following the Lyot model, was designed and built in Cambridge. After a brief period of testing at our Agassiz station in Harvard, Mass., the coronagraph in 1940 was moved to Climax, Colo., where Menzel had prepared an observatory especially for the purpose of solar observing at an altitude of more than two miles. At that time, Walter O. Roberts, a graduate student in solar astronomy under Menzel, went to Climax to put the instrument into regular operation.

Thus began research programs that may well be epochal in the study of our nearest star. Through the collaboration of Dr. Roberts, now director of the High Altitude Observatory, and Dr. John W. Evans, superintendent of the

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SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $4.00 per year in the United States and possessions; $7.00 for two years; $10.00 for three years. Add $1.00 per year for Canada and for all other foreign countries, including Latin America, making the total subscription $5.00 per year, $9.00 for two years, and $13.00 for three years. Canadian and foreign remittances should be made in United States currency. Single copies, 35 cents, foreign 45 cents. Circulation staff: Nancy R. Bolton, manager; Virginia K. Cox.

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Editorial and advertising offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, bearing adequate return postage, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited manuscripts.

The principal articles in SKY AND TELESCOPE, beginning with Vol. XII, are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

This painting of the zodiacal light as viewed in the Peruvian Andes at 14,600 feet was made by D. Owen Stephens. The engraving is from a color reproduction in The SKY, May, 1939.

The Zodiacal Light and the Solar Corona

By F. E. Roach
Naval Ordnance Test Station
AND
G. Van Biesbroeck
Yerkes Observatory

PIONEERS on the earth's first artificial satellite, after a few days of "getting settled," will doubtless send back messages about the beauties of the daytime sky. In the absence of the glow caused at the earth's surface by the scattering of sunlight in the atmosphere, the sky will be studded with the stars, planets, and the moon, as we see them now at night. However, one important difference will be immediately noticed.

Extending outward from the sun along the ecliptic will be a glow, bright near the sun, where it will be lost in the light of the inner corona, and becoming fainter at increasing angular distances from the sun. Ten degrees from the sun the glow will be 1,000 times fainter than where it blends into the inner corona, but still about 100 times as bright as the general sky background in regions well away from the ecliptic. Thirty degrees from the sun the intensity will be reduced by another factor of 10.

The satellite observer will associate the entire phenomenon with the zodiacal light, which is visible from the earth's surface at intermediate and low latitudes after the end of twilight and before the onset of dawn.

This prediction is given confidently even though no one has yet seen the phenomenon as described above. The confidence is based on the observational fact that measures of the brightness of one component of the solar corona and of the zodiacal light can be described by a single equation; this same expression satisfies the interpolation curve between the solar corona and the zodiacal light, as shown in Fig. 1. The equation of the dashed interpolated region is $\log H = 6.26 - 2.30 \log \varepsilon$, where H is the brightness in units of 10^{-15} times the brightness of the center of the sun, and ε is the angular distance in degrees from the center of the sun.

As usually photographed at the time of an eclipse, the corona is, near the sun's limb, predominantly a true corona associated with the sun, but a false corona or contamination becomes progressively evident at increasing distances from the limb. Even one degree from the sun's edge the true corona is in general much weaker than the false corona. Unfortunately, the scattered light in the earth's atmosphere makes it normally impossible to follow the coronal effect very far from the sun.

The method used to separate the two components of the corona is spectrographic—the light from the true corona, called the K-corona, has a continuous spectrum, whereas the contamination has a spectrum like the sun's, with dark Fraunhofer or absorption lines, and is called the F-corona.

It was suggested by W. Grotrian in 1934 that the F-corona is actually sunlight reflected by particles nearly in the line of sight between the earth and the sun, but not necessarily physically close to the sun. Since a widely accepted explanation of the zodiacal light is that

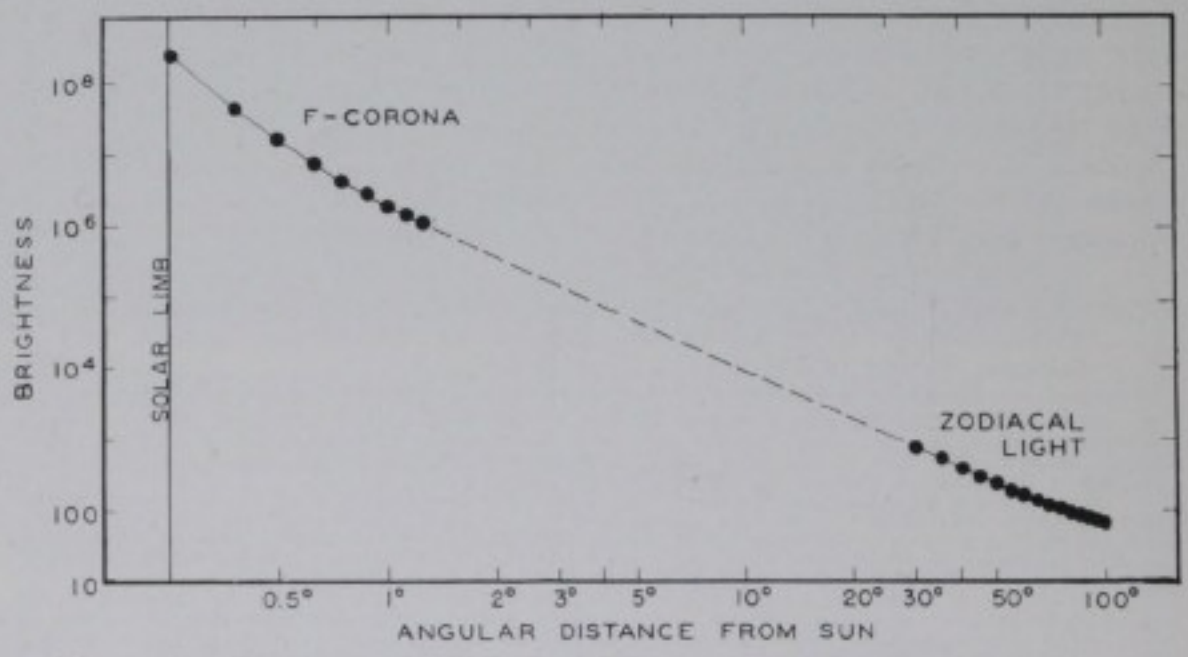
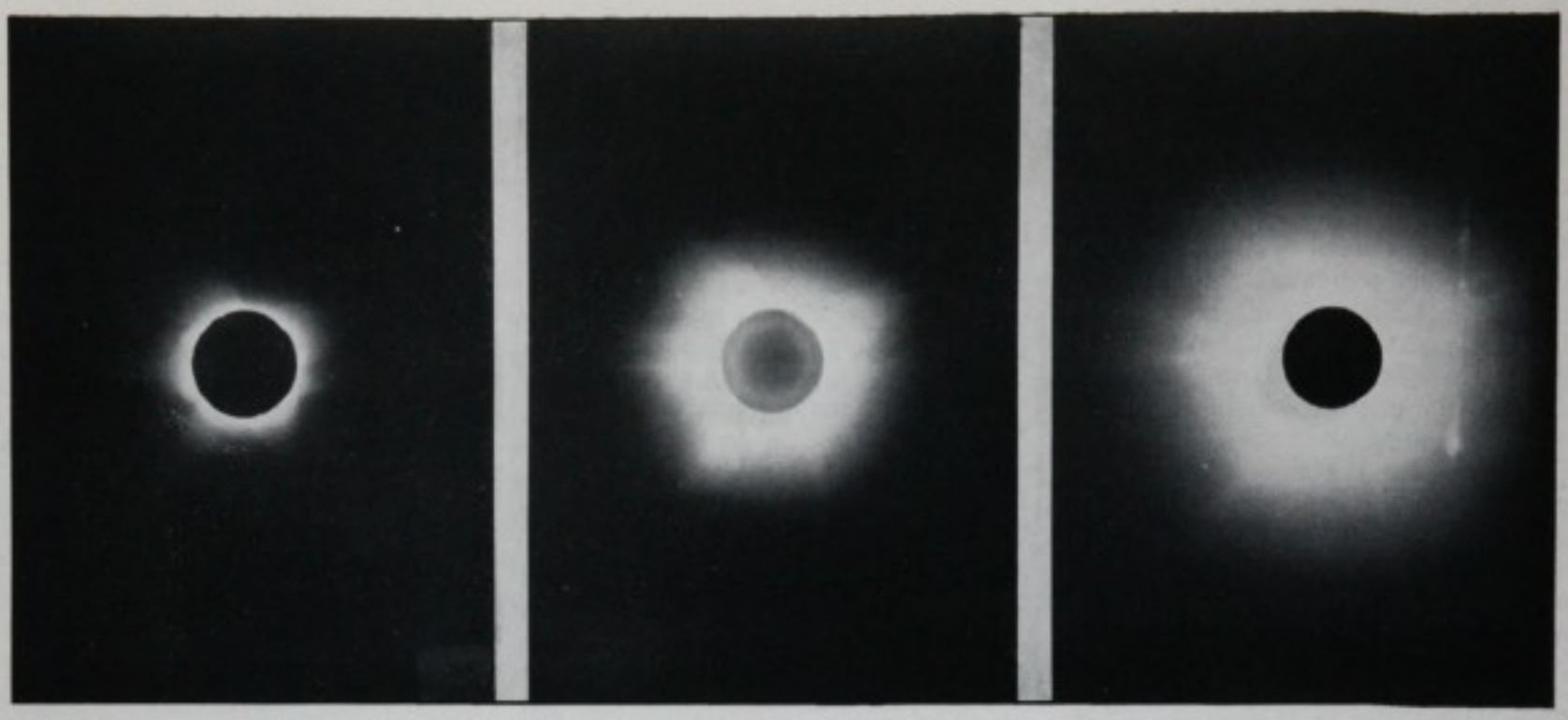


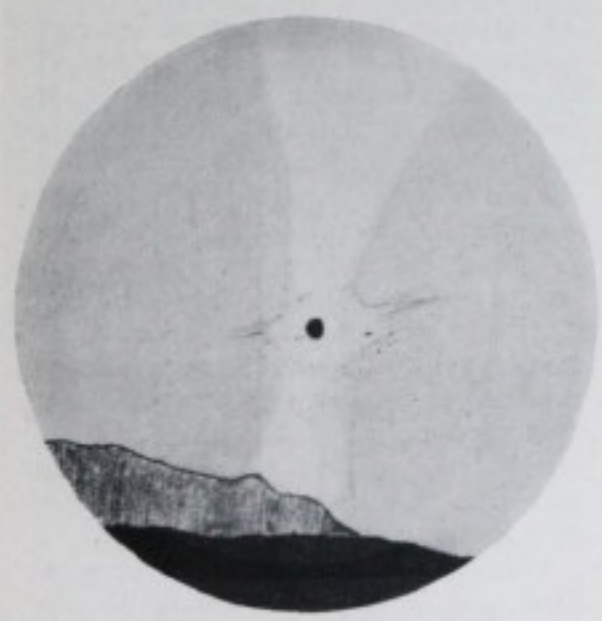
Fig. 1. The F-corona and the zodiacal light fade with increasing distance from the sun according to the same law. This diagram is part of an article on the zodiacal light by Dr. Roach and his associates, which is appearing in the "Astrophysical Journal."



The outer corona, photographed at the June 19, 1936, eclipse, by I. I. Putilin, of the Kiev Observatory, with a 6-inch f/12 lens. These exposures were one, two, and five seconds, respectively, on Ilford Monarch plates. Coronal streamers extend outward about four solar radii in the third picture, where the vertical light streak is a defect on the original negative. Engraving, courtesy the "Astrophysical Journal."

it is also sunlight reflected (modern theories say "diffracted") by particles concentrated near the plane of the ecliptic, it is natural to consider the two phenomena as really one. This point of view was taken by Grotrian and following him by C. W. Allen and by H. van de Hulst. The drawing on the front cover shows an artist's conception of how the F-corona and the zodiacal light may be associated.

Observations of the zodiacal light are usually restricted to angles of elongation *greater* than 25 to 30 degrees from the sun. The cause of this restriction is the strong twilight which predominates along the horizon unless the sun is at least 18 degrees below it. If the ecliptic rises or sets vertically and observations are made five degrees above the horizon, it is at best possible to get data 23 degrees from the sun. However, in general the ecliptic is not vertical, and most published data begin at an elongation of 30 degrees. We thus have an unobserved portion of the curve from an elongation of one degree (the outer limit of F-corona data) to 30 degrees elongation (the inner limit of zodiacal light observations).



This drawing was made by Charles H. Smiley from his Schmidt camera photographs of the 1937 total eclipse. The almost vertical band of light may be identified with the zodiacal light.

We have noted that the interpolation curve between the two sets of observations is satisfactorily represented by the same equation as each phenomenon separately. But to scientists, interpolations are exceeded as objects of disrepute only by extrapolations. The question is, who will be the first to fill in the observational gap—the satellite passenger or the earth-bound scientist? If we earthly folk are to win the race, we must devise some new method of eliminating the sky glare that now hinders us.

During the eclipse in February, 1952, two recent attempts were made.* In one case, observations at Khartoum were made in the near infrared where the scattered light is less than in the visible part of the spectrum (D. E. Blackwell, *Monthly Notices, 112,* 652, 1952). In the second, photographs were made over Saudi Arabia with a Schmidt camera by an observer flying at an altitude of 32,000 feet, where the scattered light is significantly reduced in intensity (W. Rense, J. Jackson, and B. Todd, *Journal of Geophysical Research, 58,* 369, 1953). Both attempts were partially successful, but there was so much scattered light even under these favorable conditions that the results were difficult to interpret.

Some years ago, E. O. Hulburt suggested that conditions for observing the inner zodiacal light might be favorable during an eclipse of the sun if the observer were so located that the eclipse would occur just below his horizon. In such a case, the twilight (or dawn) intensity would be reduced and, if the diminution of intensity were sufficiently great, the zodiacal light might be observable closer to the sun than under non-eclipse conditions. Because of the widespread interest in the eclipse of June 30, 1954, and the fact that the predawn eclipse region goes across Nebraska and Colorado, we have made a preliminary study of the problem for presentation here.

The physical problem is complicated by the fact that the dawn intensity increases by over 400,000 times as the sun rises to the horizon from a depression of 18 degrees, whereas for the zodiacal light the predicted increase is only 40-fold as the elongation changes from 25 to five degrees. Thus, an eclipse that is total right on the horizon would have to produce a 10,000-fold decrease in the twilight intensity in order to permit observations of the zodiacal light. At the eclipse of May 20, 1947, in Brazil, the zenith sky brightness was reduced by a factor of 4,000, which suggests that the prospects are marginal but not hopeless, especially if some additional improvement is obtained by working in the near infrared.

To visualize the geometry of the situation, let us consider the shadow pro-

*At the total solar eclipse of June 8, 1937, Charles H. Smiley, Brown University, procured small-scale photographs, with a 4-inch f/1 Schmidt camera at an altitude of 14,000 feet, that showed a double wedge of light extending along the ecliptic from the sun. See *The Telescope*, January-February, 1938, from which the engraving is here reprinted.—ED.

jected by the moon approaching the earth's surface. The angle of the shadow cone is only half a degree, and therefore the cone is so nearly a cylinder in the vicinity of the earth that we assume it to be one in Fig. 2. As long as the cone is some distance above the earth (Fig. 2a), an observer at *O* will receive direct sunlight somewhat reduced in intensity, since the sun will be seen partially eclipsed. The shadow cone in the upper atmosphere will have hardly any effect on the general illumination at *O*.

The situation is quite different in Fig. 2b, where the axis of the cone is just tangent to the earth at *O*. This is now the point where the total eclipse begins, and here the sun will be seen totally eclipsed on the horizon. The atmosphere is dark over a height equal to the radius of the cone.

A few minutes later (Fig. 2c), the cone ends at the surface of the earth. The sun is seen totally eclipsed from points inside the shadow, but at *O* the shadow no longer affects the illumination of the atmosphere.

It is evident that only in the case of Fig. 2b will the cone of shadow help in making the inner zodiacal light visible. We will, therefore, examine this situation more closely, in Fig. 3. If we cut the atmosphere by a plane normal (at right angles) to the axis of the cone at *O* (Fig. 3a), the observer is seen to be in the center of a dark cylindrical tunnel (Fig. 3b). For him the sky will not, however, be completely dark; aside from the light scattered by the particles of our atmosphere outside of the dark tunnel, there will also be the illumination by the inner corona.

As mentioned above, during the 1947 eclipse the illumination of the sky in the zenith was found to be reduced by a

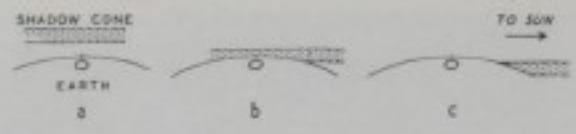


Fig. 2. The location of the shadow cone with respect to the point O is shown here, for instants of time occurring before, during, and after totality.

factor of 4,000. The diameter of the cone was 107 miles at that time. At the coming eclipse of June 30th, the diameter is only 68 miles, so that the reduction of illumination will be less. But there is the advantage that for an observer at *O* no light will come from the lower half of the cone, which is intercepted by the earth. The 1947 eclipse was observed in the middle of the day, and diffuse light came in from all sides.

There remains, however, the light of the corona, which measurements at previous eclipses have shown to be about as bright as the full moon, enough to blot out most of the zodiacal light. We can overcome this by moving to a point *N* in a direction opposite to that of the sun (Fig. 3a). There the sun will be depressed by an angle equal to the arc *O-N* on the earth's surface, and the

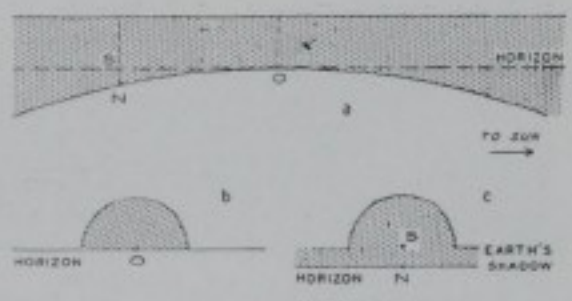


Fig. 3. A more detailed portrayal of the situation of Fig. 2b shows the effect of an observer moving from O to N, to cut off dawn and coronal illumination.

corona will be cut by the same amount. If we make a section normal to the cone at *N*, the atmosphere will appear as in Fig. 3c. The shadow tunnel tops the earth's shadow. A much greater reduction of illumination takes place, both because the earth's shadow helps darken the cone, and because inner coronal light has been cut off.

The height *N-S* of the earth's shadow center and the depression of the sun below the horizon are given in the following table, for different values of the distance *O-N* from the point of first contact of the shadow-cone axis with the surface of the earth:

Distance, miles	*Shadow height, miles*	*Sun below horizon (°)*
100	1.3	0.8
200	5.1	2.3
300	11.4	3.7
400	20.2	5.2
500	31.6	6.6

The figures in the last column have been reduced by 0°.6 to take into account the effect of refraction.

Since the brightest part of the K-corona extends to about 1½ degrees from the center of the sun, it appears that suitable sites will be found beginning 150 miles from the point of first contact of the shadow-cone axis. On June 30th, this first point is at longitude 99° 04′ west and latitude 42° 22′ north, near the town of Atkinson, Nebr., as shown in Fig. 4.

From there the cone of shadow points 58 degrees west of south along a line defined by the co-ordinates:

Longitude west		*Latitude north*	
101°	40′.1	41°	09′.4
102	41.5	40	40.9
103	29.1	40	18.8
104	45.1	39	43.7

At 150 miles from the point of first contact the line passes over the town of Ogallala, and observations could be made from there all the way to the vicinity of Denver, where totality occurs when the sun is five degrees below the horizon.

Especially useful would be photographs of the eastern sky by observers located along the path indicated in Fig. 4. There will undoubtedly be a significant amount of dawn light, even during the time of totality, but the inclination of the ecliptic is such that the maximum of the dawn will be to the north of the maximum of the zodiacal light, and the two phenomena may be separable.

Observers with fast photoelectric scanners will attempt to distinguish the dawn from the zodiacal light by horizontal sweeps along the eastern horizon. Precise suggestions as to observing procedures are difficult to make because of the exploratory nature of the work.

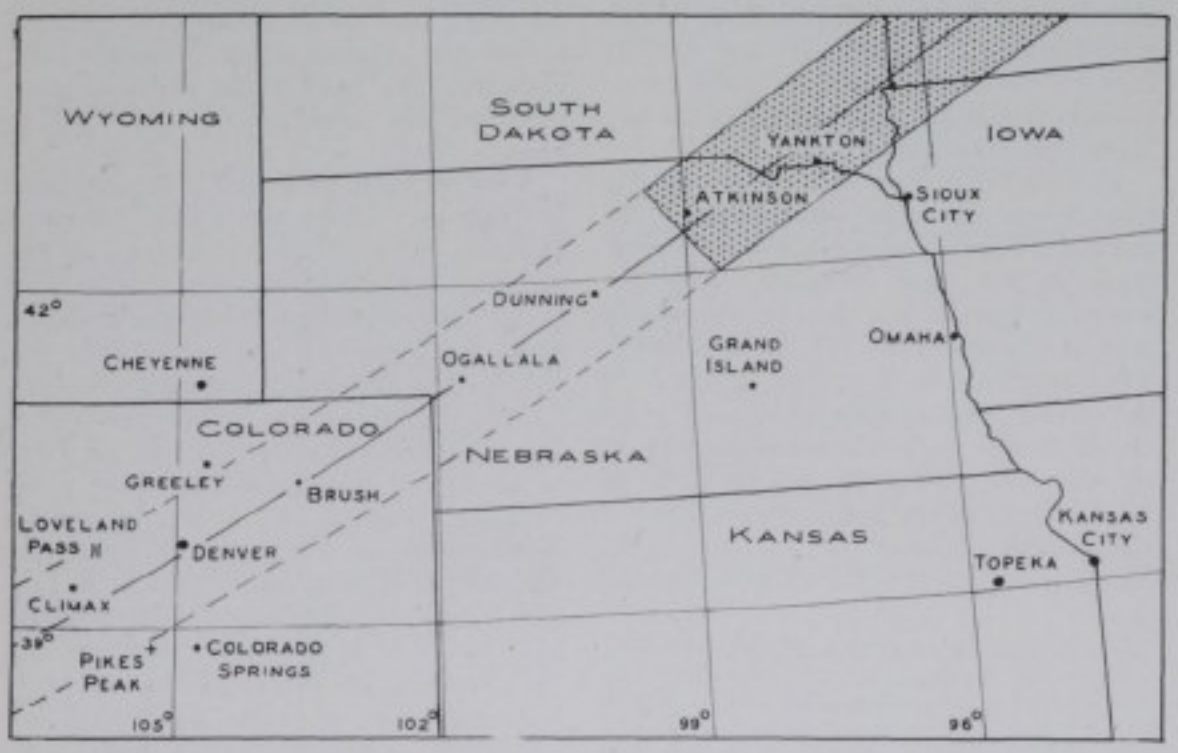


Fig. 4. The shaded area is the path of totality at the June 30th eclipse. Observers in the western extension of this zone may be able to detect the zodiacal light while the eclipse is total before sunrise.

Quantitative Spectral Classifications

By Otto Struve, *Leuschner Observatory, University of California*

In May, 1953, I discussed the spectral classifications of the stars based upon their absorption lines and bands. These classifications depend upon eye estimates of the relative intensities of certain features in the spectra of the stars—features which are sensitive to differences in stellar surface temperatures, or to differences in stellar atmospheric pressures.

The most elaborate classification of this kind is the one developed by W. W. Morgan and his associates at the Yerkes Observatory. The purpose of Morgan's work was to discover observationally those criteria that are best suited to arrange the stars in pigeon-holes, each characterized by a small range of temperature and pressure. Many of these criteria represent blends of lines and cannot, therefore, be readily interpreted in terms of the physical parameters of the star under observation, namely, radius, mass, and luminosity.

In order to improve the classification and render it suitable for a physical interpretation, two new methods have been proposed during the past few years. The first is the work of D. Chalonge at the Astrophysical Institute in Paris, while the second is due to B. Stroemgren at the Yerkes and McDonald Observatories.

The method of Chalonge and his collaborators depends upon photographic observations of the spectra of stars, principally in the ultraviolet region. They use a powerful quartz spectrograph in which the plateholder is driven by a motor around a pivot located along the axis of the spectrum, at a fixed distance from the short-wave end of the exposure. The purpose of this arrangement is to increase the effective exposure in the ultraviolet, where the light of most stars is weak and where the photographic plate is not particularly sensitive. The spectra appear wedge shaped, the band of continuous light being narrower in the ultraviolet than in the blue region.

In this manner the Paris spectra record approximately uniform intensities along the entire wave-length range to which the plate is sensitive. On page 83 of the January, 1954, issue of this magazine, we reproduced several spectra obtained with Chalonge's spectrograph.

Three fundamental quantities are measured in each spectrum. Two of these are illustrated in Fig. 1, which has been adapted from similar diagrams by Chalonge. They show for Gamma Pegasi, a *B*-type star, and for BD +44°4014, a star of class *A*, the amount of the Balmer jump, marked by the line CD; this is the first quantity. The second is the wave length of the point K, which is located halfway between D, where the continuous Balmer absorption is complete, and the point B, where it has not yet started.

The third quantity is the usual spectrophotometric gradient, ϕ, which in effect measures the slope of the energy curve of the star on the red side of the point B. The quantity ϕ is, therefore, closely related to the color index, and to the spectrophotometric temperature of the star derived by fitting a theoretical Planck curve to the observed energy curve of the star.

The Balmer jump, designated by *D*, is a measure of the number of those hydrogen atoms which are being ionized per unit of time by the ultraviolet radiation of the star's photosphere. This quantity does not give the abundance of *all* hydrogen atoms in the star's atmosphere, but only of those being ionized.

The wave length of the point K, designated by λ_1, is an indication of the broadening of the individual Balmer lines of hydrogen and is, therefore, a measure of the intensity of these Balmer lines as well as of their widths. In a supergiant, where the broadening of the hydrogen lines is small, the wave length λ_1 is very close to the Balmer limit at 3647 angstroms. In an ordinary main-sequence *A*-type star like Vega, the hydrogen lines are broadened by the Stark effect caused by ionized particles in the reversing layer of the star. This effect produces very broad wings which flow together even between the hydrogen-delta ($H\delta$) and hydrogen-gamma ($H\gamma$) lines. In such a star, λ_1 has a value of the order of 3800 angstroms.

Fig. 1. These tracings of the spectra of two early-type stars, Gamma Pegasi (above) and BD +44°4014, with brightness plotted against wave length (the latter increasing toward the right), are lettered to illustrate the three quantities measured in the Chalonge method. The spectrophotometric gradient can be evaluated from the form of the curve AB.

It is easy to see that *D* and λ_1 measure different properties of the atmosphere of the star. Since the Balmer jump is quite unrelated to the Stark effect, the quantity *D* is independent of the pressure of the star's atmosphere. On the other hand, λ_1 depends upon this pressure because, when the particles and atoms are packed close together, the electric fields of the charged electrons and ions that produce the broadening of the hydrogen lines are much larger than when the pressure is low and the particles are far apart. Of course, λ_1 also depends on the number of hydrogen atoms that are capable of being ionized. This is because, as a rule, the Balmer lines are produced most frequently from a hydrogen atom that had been ionized and has captured an electron into the second orbit of the atom. From this state the electron can be raised to a still higher state by absorbing a quantum of starlight, thus contributing to a Balmer absorption line.

We might add that in the white dwarfs, where the Balmer lines are excessively broad (as described in January), λ_1 is much larger than even in a normal *A*-type main-sequence star. It may well reach wave length 4000 or even 4100 angstroms.

Both quantities, *D* and λ_1, can be accurately measured from the microphotometer curves of the spectra. They are independent of interstellar reddening, which is a source of uncertainty in those spectral classifications that rest upon measures of the color index. Both quantities can be obtained from spectrograms of very small dispersion, of the order of 250 angstroms per millimeter, which are easier to obtain than those of the dispersion required in the Morgan classification.

The principal disadvantage of the Chalonge method is its limitation to stars in which the hydrogen lines and the Balmer jump are sufficiently marked to show on the plates. In other words, the method is good only for spectral types earlier than about *G*0.

The precision the French astronomers have reached is as good as, or possibly better than, that obtained in the Morgan classification. Fig. 2 shows the correlation of Morgan's spectral types and luminosity classes with *D* and λ_1 measured by Chalonge and Mlle. L. Divan. The maximum value of *D* is attained

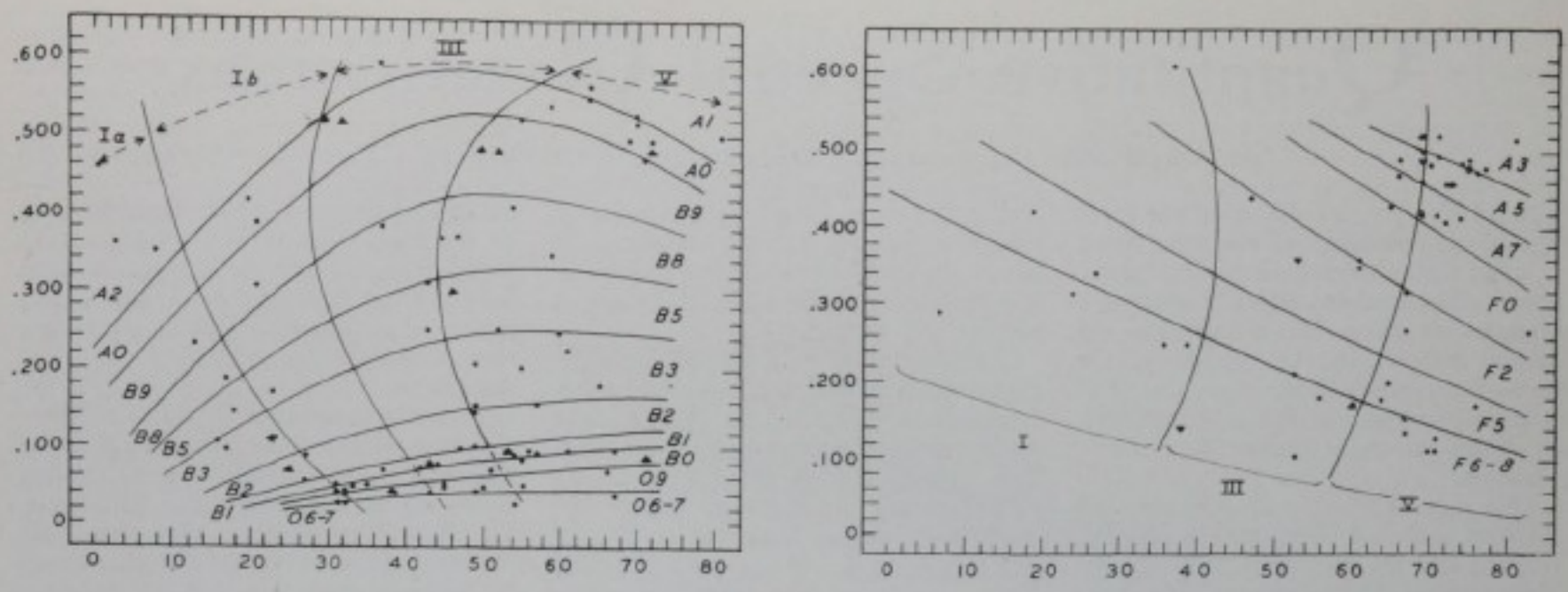


Fig. 2. Each dot is a star, plotted by Chalonge and Divan from values of λ_1 —3070 and D, represented by the horizontal and vertical scales, respectively. Morgan's spectral types extend roughly horizontally; his luminosity classes, vertically. Each triangle is a star whose Paris and Yerkes classifications disagree. Adapted from "Annales d'Astrophysique."

along the spectral sequence at about class *A0*. The left portion of the diagram contains stars hotter than this, for which *D* has less than the maximum value; on the right are those stars on the cool temperature side of the maximum value, for which *D* becomes smaller at later spectral classes. The network of curves makes it possible to convert the French measures into the spectral types and luminosity classes of Morgan.

In order to illustrate even more strikingly the relations between the French system and the Morgan types and luminosity classes (described last May), Chalonge and Mlle. Divan have prepared a plaster-of-Paris model illustrated in Fig. 3. The horizontal co-ordinates are λ_1 (along the front) and *D* (from front to back). The vertical co-ordinate is the spectrophotometric gradient, ϕ, which measures the temperature; the hot stars are at the bottom, the cooler stars at the top. The black lines on the surface of the model show the conversion of the French system into the system of Morgan. The peculiar bending over of the surface is caused by the fact that the Balmer jump first increases with diminishing temperature and then decreases.

In making use of this model, astronomers must take into account the fact that the spectrophotometric gradient depends upon interstellar reddening; therefore, for distant stars the measured values of ϕ must be corrected for interstellar absorption. It should also be remembered that the Morgan classification applies only to stars of Population I, and the conversion curves have to be used with caution for stars of Population II.

Nevertheless, Chalonge's model has already led to some interesting results with regard to stars of Population II. One of Chalonge's associates, Mlle. A.-M. Fringant, has recently investigated the spectrum of the famous galactic cluster-type variable, RR Lyrae. She found that at maximum and minimum brightness RR Lyrae is characterized by the following values:

λ_1	3741 and 3739 angstroms
D	0.511 and 0.261
ϕ	1.55 and 2.05
Spectra	*F*0 II and *F*8 II

When the three Chalonge parameters are plotted in the model, it is found that the representative points of RR Lyrae fall consistently below the surface. In other words, this Population II star cannot be represented by the surface; its gradient is always smaller than would correspond to the surface as defined by the Population I stars. Thus RR Lyrae is always bluer than Population I stars with similar values of *D* and λ_1.

Exactly the same tendency is exhibited by several subdwarfs of Population II which have been studied by Chalonge, J. Berger, Mlle. R. Canavaggia, and Mlle. Fringant. Again these stars fall below the surface of the model and are,

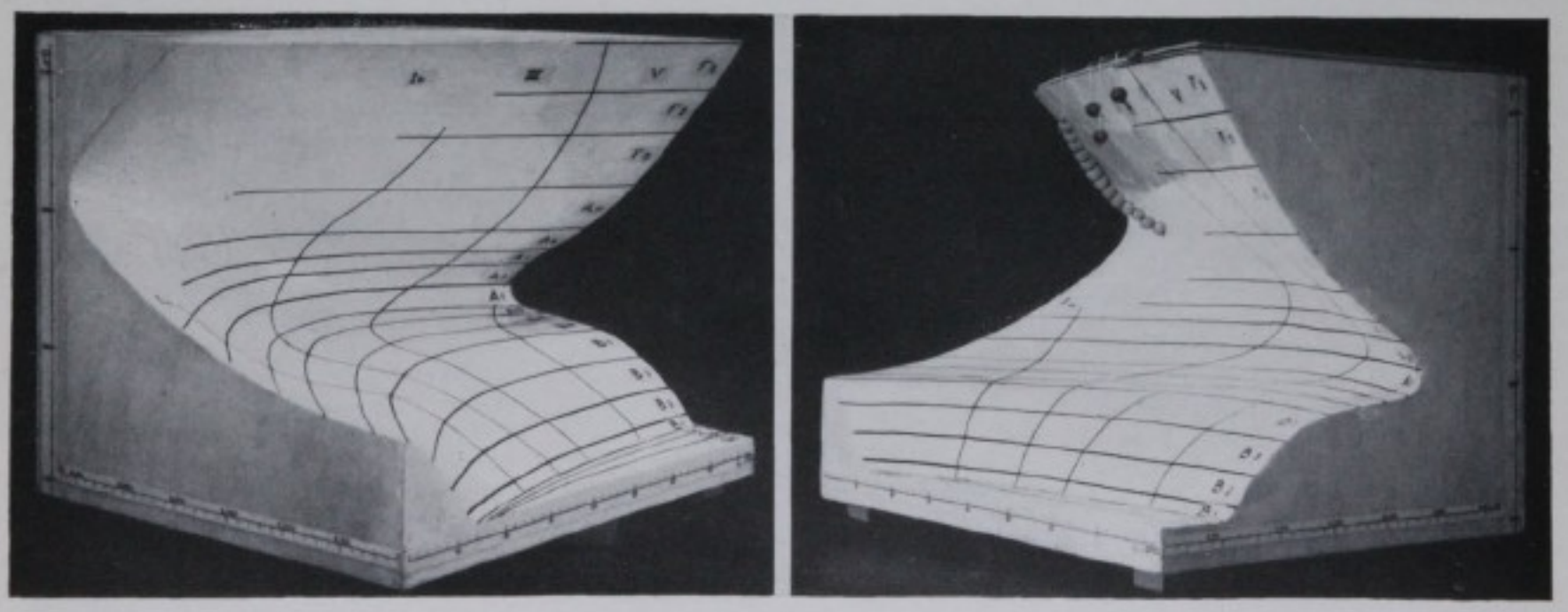


Fig. 3. Two views of the Chalonge-Divan model for Population I stars. The beads are for a few Population II stars.

therefore, bluer than normal stars.

In the right-hand part of Fig. 3, the string of beads suspended below the upper part of the cast surface represents the successive values of D, λ_1, and ϕ, which RR Lyrae assumes in the course of its half-day cycle of variation. The four separate beads, also suspended below the surface, represent four subdwarfs of Population II.

The principal advantage of the Chalonge method is its dependence solely on the properties of the hydrogen atom. It should, therefore, be possible to use his scheme in future investigations of many problems involving spectral types, such as the interpretation of the H-R diagram, the relation between the ages of the stars and their hydrogen abundances, and so on.

The second of the new methods for quantitative spectral classification is Stroemgren's. In principle, the investigations by Stroemgren are quite similar to those of Chalonge, but while the latter uses spectrograms, the former examines directly the light of each star with a photoelectric photometer. Various wave lengths of the star's light are isolated by interference filters and compared. A two-dimensional classification is established for B, A, and F stars based on measures of the strength of the hydrogen-beta ($H\beta$) absorption line and of the Balmer discontinuity.

For $H\beta$, three filters are used with maximum transmission at 5000, 4861, and 4700 angstroms, respectively. The middle one of these is for the absorption line itself; the other two filters furnish comparison intensities from regions where the spectrum is essentially continuous. For the Balmer discontinuity index, filters passing 4500, 4030, and 3550 angstroms are used. The last of these is situated where the continuous Balmer absorption is strong. Both indices are practically uninfluenced by interstellar reddening. The half-width of the $H\beta$ filter is 35 angstroms; the other filters have half-widths around 100 angstroms.

Stroemgren calibrated his method by measuring about 100 stars for which Morgan classes and luminosity types were known. He found that he can classify spectral types to about 0.02 spectral class. This so far exceeds all previous methods of classification that it constitutes a new epoch in astrophysics. Similarly, the absolute magnitudes of the stars to which this method applies are obtained with a probable error of only about 0.2 magnitude from a single observation.

For cool stars of type K, similar work with other criteria has been carried out at Copenhagen Observatory, by K. Gyldenkaerne, with satisfactory results.

At the Nashville meeting of the American Astronomical Society, Dr. Stroemgren described a further advance in observing techniques. Simultaneous photoelectric photometry with photon counters of three narrow wave-length regions ($H\beta$ and two comparison regions) has been carried out. Here the spectrum is actually produced, by the coude spectrograph of the 82-inch McDonald Observatory reflector, and slits are used to select the three narrow regions. He pointed out that while the interference filter method used with the 82-inch yields high precision down to about the 12th magnitude, the method of simultaneous measures extends the range down to the 14th magnitude. For equal precision the gain over the photographic method is about four magnitudes when the photoelectric accumulation time is equal to the photographic exposure time.

It is clear that these new methods open up fresh vistas for the astrophysicist. We can now investigate whether there are really cosmic differences between the spectral types of stars known to have identical values of mass, radius, and luminosity. Two of the most interesting problems suggested by the new methods are the following:

Can two stars, identical in mass, luminosity, and radius, differ in atmospheric composition? Such differences might, perhaps, be expected if some stars happen to travel through dense clouds of interstellar dust and gather up by the process of accretion appreciable quantities of this dust. Other stars traveling through empty regions of the Milky Way would possess "uncontaminated" atmospheres whose composition would be similar to that of the original medium out of which each star was condensed.

Does the axial rotation of a star produce an effect upon its absorption features? We have usually assumed that it does not, and that rotation (unless it is very large) can be disregarded in spectral classification work. However, O. J. Eggen has shown that this assumption is probably incorrect. When we think of the sun, with its pronounced latitude effects in the distribution of spots and prominences, it would be reasonable to expect that moderately large rotational velocities in stars might trigger off violent prominences which could easily modify the absorption features of their spectra without in any way affecting the other characteristics, such as mass, luminosity, and radius.

HARVARD OBSERVATORY DIRECTOR APPOINTED

(Continued from page 143)

Upper Air Research Observatory of the Air Force Cambridge Research Center, solar astronomers under Menzel's scientific guidance are well on the way to putting into operation two large coronagraphs, one at Climax and the other at Sacramento Peak, N. M.

With the coming of the second World War, more than a score of the observatory staff undertook various assignments for the duration of the national emergency. Menzel was on leave of absence from Harvard University for nearly three years, first as a lieutenant commander in the U. S. Naval Reserve, and later as commander, and chairman of the Wave Propagation Committee of the Joint and Combined Chiefs of Staff.

To his new responsibilities Dr. Menzel brings not only his valuable experience in developing the two solar stations, but experience in the classroom, and in the guidance of research students in astrophysics. His numerous publications include contributions on stellar spectra, planetary nebulae, the atmospheres of planets, atomic theory, in addition to extensive work in many phases of solar astronomy. A notable series of 18 papers, on "Physical Processes in Gaseous Nebulae," was published between 1937 and 1945 in the *Astrophysical Journal*, many of them being his joint contributions with J. G. Baker, L. H. Aller, Leo Goldberg, and others.

Dr. Menzel is a member of the National Academy of Sciences, the American Philosophical Society, and of the usual professional organizations. He is a three-time winner of the A. Cressy Morrison prize of the New York Academy of Sciences.

Harvard University has also announced that, with the inauguration of a new administration at the observatory and the reorientation of a part of its program, a substantial sum has been set aside for the construction of an additional office building, replacing one of the century-old frame structures. Also, funds are provided that will permit the overhauling and improvement of the instrumental equipment at the Agassiz station. The future of that important part of the observatory will include further development of the radio astronomy work which, under the supervision of Dr. Bart J. Bok, has in the past year become highly significant.

The observatory will continue to operate two meteor observing stations near Las Cruces, N. M.; these are the scientific responsibility of Dr. Fred L. Whipple, who also is chairman of the department of astronomy at Harvard University. Indeed, the whole research program of solar, meteor, galactic, and radio astronomy, supplemented with strong emphasis on theoretical astrophysics and graduate school instruction, looks both bright and challenging.

Dr. Menzel is the sixth director of Harvard College Observatory since its founding 115 years ago. The first four directors were William C. Bond, George P. Bond, Joseph Winlock, and Edward C. Pickering.

HARLOW SHAPLEY

American Astronomers Report

Here are highlights of some papers presented at the 90th meeting of the American Astronomical Society at Nashville, Tenn., in December. Complete abstracts will appear in the Astronomical Journal.

Delta Aquarid Meteors

The unique character of the orbit of this meteor stream, previously recognized from radar observations in England and Canada, has been studied at Harvard Observatory by Miss F. W. Wright, Dr. F. L. Whipple, and Dr. L. G. Jacchia. From five doubly photographed meteors, the perihelion distance is 0.061 astronomical unit, considerably smaller than for any other meteors yet photographed and reduced. The stream moves in a highly elongated orbit, with an eccentricity of 0.98, so that its aphelion is near the orbit of Jupiter. The period is about 4.2 years.

Perturbations by Jupiter and the destructive effects of solar radiation both tend to dissipate the Delta Aquarid stream; it must therefore be young to be still observable. In fact, its meteoroids may undergo some changes in physical structure each time they pass through perihelion, where they are heated to temperatures in excess of 1,000° K.

The Geminid meteor stream bears the closest resemblance to the unique Delta Aquarids, but for the Geminids perihelion distance is 0.14 astronomical unit, the eccentricity is 0.90, and the greatest distance from the sun is only halfway out to Jupiter's orbit.

New Emission Regions

At Yerkes Observatory, W. W. Morgan, B. Stroemgren, and H. M. Johnson have surveyed the northern Milky Way from Aquila to Canis Major. Their photographs were taken with a new Schmidt-type camera, designed by A. B. Meinel and built by Fred Pearson. It is an 8-inch, f/1, flat-field aspheric system, with a 10-degree field. The plate-filter combination records a narrow band of wave lengths centered on the hydrogen-alpha line.

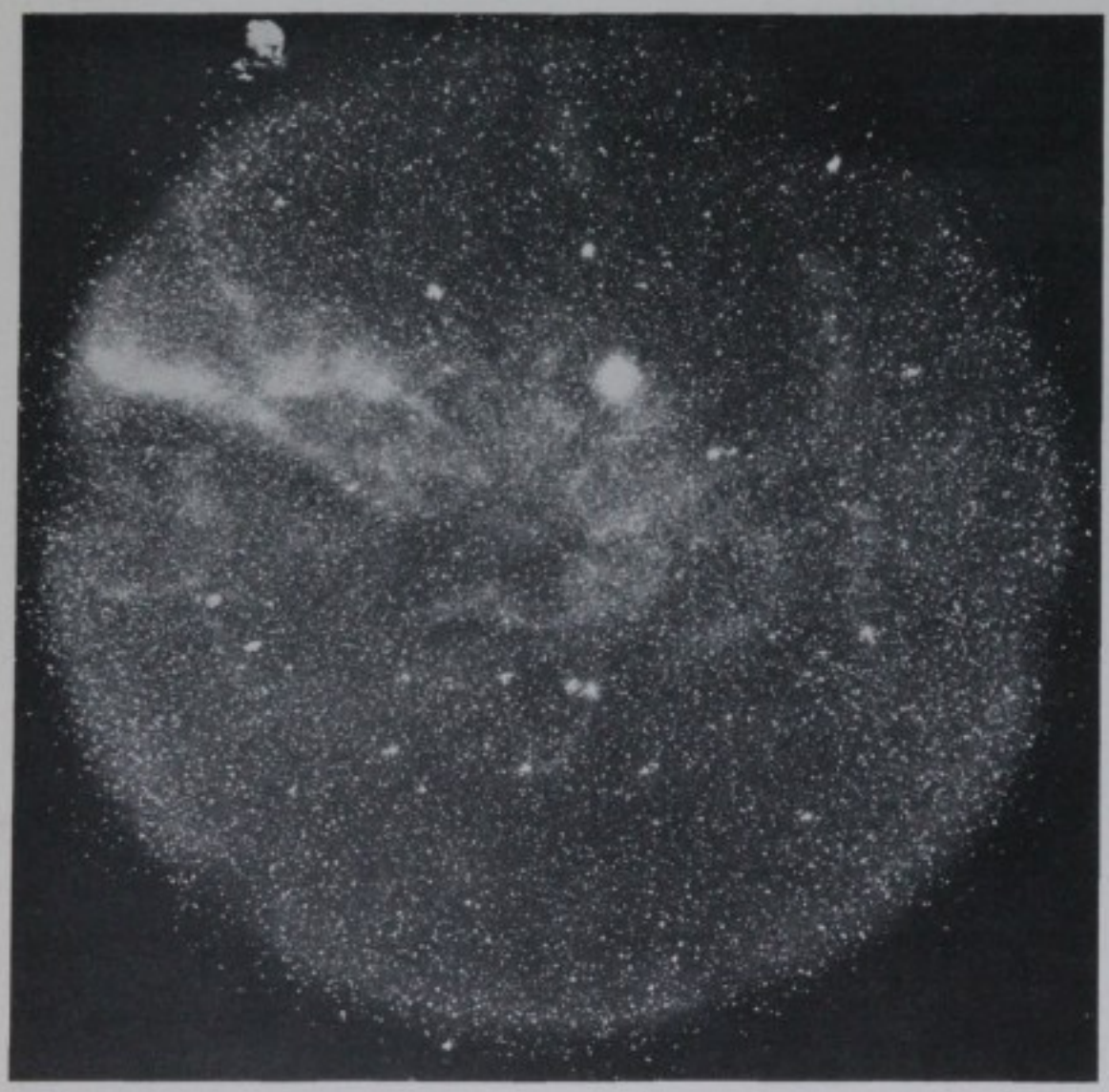
The current report on this survey, dealing with the region from Perseus to Monoceros, describes many new features of hydrogen-emission nebulosity. Near the star Xi Persei, the well-known California nebula is now found to have faint extensions, indicating that it is the brightest part of a large H-II shell. These extensions are visible in the facing full-page photograph, but the faintest portions of the loop, which Dr. Morgan regards as "probably recorded," do not show in the reproduction.

A number of apparently new features have been photographed in the Orion region. One of the most interesting is a field of faint nebulosity with complex structure in the neighborhood of the 1st-magnitude star, Rigel, shown in the picture below. This nebulosity makes it practically certain that Rigel is a member of the Orion association, and from this it follows that the visual absolute magnitude of this supergiant star is between −8.0 and −8.5.

Another feature in Orion is a long nebulous extension from the great Orion loop northward to Betelgeuse. The drawing on page 152 suggests how the whole complex of Orion nebulosities would appear to an eye highly sensitive to the red light of hydrogen. The drawing is like a negative print of a photograph, in which dark regions represent bright emission areas. The brighter stars of the constellation have been added, and the belt lies across the middle of the picture. Circular arcs mark the limits of six fields of the Meinel-Pearson camera, each 10 degrees in diameter.

A drawing has been utilized to show the results of the survey in Orion because of the near impossibility of matching neighboring high-contrast photographic prints, and to avoid spurious features which vary from plate to plate and whose intensity is enhanced in the copying process.

The Yerkes astronomers exhibited other photographs of features associated with stars in Monoceros. The star 12 Monocerotis is found to be located on the periphery of a large nebulous ring about four degrees in diameter. Another region of about the same size, exceeding-



This is a plate in hydrogen light of the region around Beta Orionis (Rigel), which is above the center. The Orion nebula is at the left upper edge of the engraving. The circle of this field matches the lowest segment of the Orion composite drawing on page 152. Yerkes Observatory photograph.

FACING PICTURE: On ordinary blue-light photographs only the brightest portion of the California nebula appears. It is located north of the star Xi Persei, which is just below the main part of the nebula in this enlargement. This is a 30-minute exposure in hydrogen-alpha light with the f/1 Meinel-Pearson Schmidt camera. Notice the extensions of the California nebula to the left and downward, and nebulosity in other parts of the field. The very bright star in the center of the lower part of the picture is Zeta Persei, and Omicron Persei is in the lower right corner. Yerkes Observatory photograph.

A drawing of the emission nebulosity in Orion, from Yerkes Observatory negatives taken in hydrogen-alpha light. North is at the top, with Betelgeuse at the upper left, the Belt near the center. A positive photograph of the Rigel area appears on page 150. Yerkes Observatory drawing.

ly complex, contains the star S Monocerotis. The lower part of the S Monocerotis loop overlaps the northern part of that associated with 12 Monocerotis.

Other new features will be described later, in the course of this work carried out under a grant from the National Science Foundation.

OPTICAL SOCIETY

On March 25-27, the Optical Society of America will hold its spring meeting at the Hotel Statler in New York City. The meeting is open to nonmembers, who may secure copies of the program in advance from the society secretary, Dr. Arthur C. Hardy, Massachusetts Institute of Technology, Cambridge 39, Mass.

Pseudo Cluster-type Variables

Cluster-type variables are pulsating stars belonging to Population II with periods less than about 1.3 days. Their space distribution and their motions have proved to be powerful tools in recent galactic research. It is therefore disconcerting to find that many of these stars may turn out to be misclassified eclipsing variables belonging to Population I, as reported by Harlan J. Smith, Yale University Observatory.

At the Agassiz station of the Harvard Observatory, Mr. Smith secured accurate photoelectric light curves in blue and yellow light for selected cluster-type stars. The first two variables investigated of subtype c (characterized by nearly sinusoidal light curves) were UZ Leonis and FG Hydrae, and both were found to be actually eclipsing binaries. Spectrographic observations of the former star confirm its binary nature.

If many other stars of subtype c turn out to be misclassified, Mr. Smith pointed out, important conclusions that have been drawn concerning cluster-type variables may need some revision. In the absence of extensive photoelectric observations, only those cluster-type stars with markedly asymmetric light curves can be regarded as bona fide.

Planets from a Super-Prominence?

Theories of the origin of the solar system postulating that the material that formed the planets came originally from the sun meet difficulty from the fact that the planets have 98 per cent of the angular momentum of the solar system, while the sun has only two per cent.

Dr. Donald H. Menzel, Harvard Observatory, has outlined a new mechanism that might explain this property of the planetary system, based on his earlier suggestion that solar prominences probably result from the action of electric currents.

The planets would have formed from a super-prominence with a mass about five times that of Jupiter. This prominence would start as a doughnut-shaped current loop, surrounding the sun's equator. Forces acting on the loop might cause it to escape from the sun, carrying with it conductive matter entangled in the magnetic lines of force, to form a kind of super-prominence.

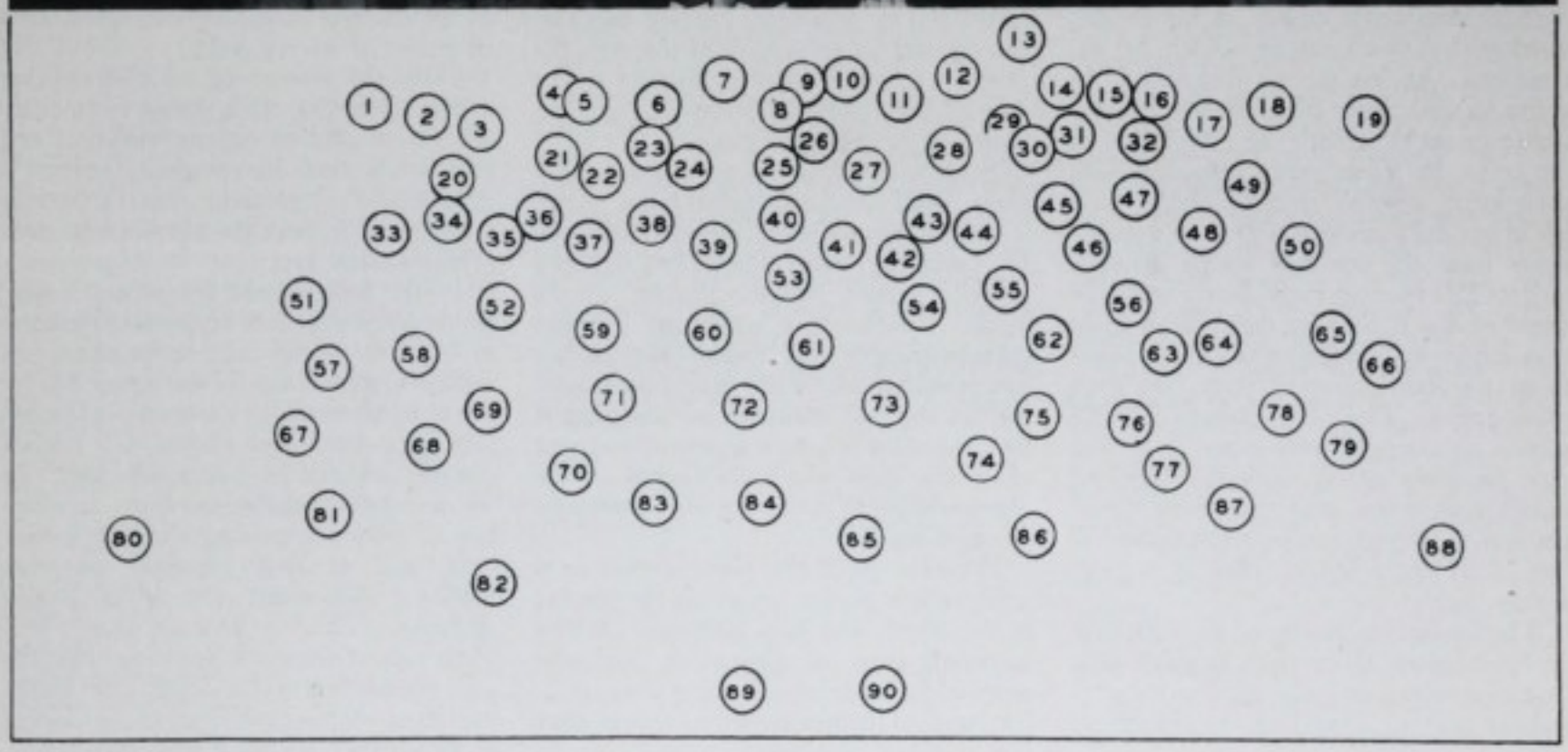
While Dr. Menzel did not examine in detail the subsequent condensation of the ejected matter, he pointed out that the stretching of the magnetic lines of force joining the ring with the sun would give the ring high tensile strength and prevent it from being disrupted by Roche forces. The magnetic linkage would also exert a braking action on the sun, and while expanding the superprominence would gain angular momentum at the expense of the sun.

The Harvard astronomer stated, "The model is, of course, highly speculative and requires additional analysis before it merits much consideration."

"Astronomical Figures"

Last night I saw a nebula
Depict a polar bear:
Arched neck and upraised paw
Were there —
Such snowland scenery everywhere,
That in my mind I saw much more —
Fat Eskimos upon the shore,
Their fishing gear,
The furs they wore,
An arctic hare
Being put to rout;
Heard huskies bark and hunters shout
And even the Arctic Ocean roar
From skies as silent as before.

CHARLES HETZLER



The 90th meeting of the American Astronomical Society, Vanderbilt University, December 27-30, 1953. Photo by Ken Spain.

KEY TO PHOTOGRAPH

1, A. Blaauw, Ye; 2, A. E. Whitford, W; 3, C. M. Huffer, W; 4, C. Federer, H; 5, W. L. Moore, U of Louisville; 6, O. Mohler, McM; 7, B. Stroemgren, Ye; 8, A. Cox, Los Alamos; 9, K. Pierce, M; 10, A. Sandage, MWP.

11, R. H. Wilson, U of Louisville; 12, J. Irwin, I; 13, P. Herget, C; 14, I. King, U. S. Navy; 15, D. V. Guthrie, Louisiana State U; 16, W. Liller, M; 17, A. Cook, H; 18, D. Duke, U of Florida; 19, Miss A. Hearn, H; 20, P. Musen, C.

21, Miss G. Gjellestad, Ye; 22, R. Huffer, Beloit Coll; 23, Mrs. Musen; 24, W. Calder, Bradley; 25, J. Cuffey, I; 26, F. Kameny, U of Arizona; 27, M. S. Roberts, MWP; 28, L. W. Plum, I; 29, L. Goldberg, M; 30, R. Hardie, Lowell.

31, K. Yoss, Wilson Coll; 32, H. W. Cornell, Milwaukee, Wis.; 33, R. Mathews, Van Vleck; 34, N. T. Bobrovnikoff, Ohio State U; 35, Mrs. R. Huffer; 36, J. G. Baker, H; 37, R. Tayler, Pr; 38, I. Malitson, Washington, D. C.; 39, J. H. Rush, Col; 40, J. Cox, I.

41, Miss J. Sweeney, H; 42, J. Stock, WS; 43, V. Blanco, WS; 44, Hugh Johnson, Ye; 45, W. Wehlau, Lick; 46, E. Weston, David Dunlap; 47, J. Merrill, P; 48, Mrs. H. Malitson, Washington, D. C.; 49, Miss M. Calvert, Nashville, Tenn.; 50, A. Spitz, Spitz Laboratories.

51, C. Wade, H; 52, Jean Bobrovnikoff; 53, Miss E. Flather, Sproul; 54, J. B. Oke, David Dunlap; 55, Mrs. Johnson; 56, H. R. J. Grosch, General Electric Co.; 57, R. G. Athay, Col; 58, Mrs. Baker; 59, M. Savedoff, U of Rochester; 60, H. A. Abt, Lick.

61, Mrs. Wehlau; 62, H. Shapley, H; 63, Mrs. Grosch; 64, D. Liebenburg, W; 65, Mrs. Spitz; 66, C. Perry, I; 67, G. C. McVittie, U of Illinois; 68, S. Wyatt, U of Illinois; 69, J. C. Pecker, Col; 70, R. Sears, I; 71, D. Layzer, H; 72, H. Albers, WS; 73, T. Matthews, H; 74, J. W. Chamberlain, Ye; 75, O. Gingerich, H; 76, E. K. Rabe, C; 77, R. T. Grenchik, I; 78, R. Brownlee, I; 79, R. Hallam, W; 80, R. Means, Nashville, Tenn.

81, E. R. Dyer, McCormick; 82, M. Schwarzschild, Pr; 83, L. Spitzer, Pr; 84, D. B. McLaughlin, M; 85, R. R. McMath, McM; 86, C. K. Seyfert, Dyer; 87, G. M. Clemence, U. S. Naval; 88, Mrs. Dyer; 89, Virginia Dyer; 90, Barbara Dyer.

C, Cincinnati; Col, Colorado; H, Harvard; I, Indiana; M, Michigan; McM, McMath-Hulbert; MWP, Mount Wilson-Palomar; P, Perkins; Pr, Princeton; W, Washburn; WS, Warner and Swasey; Ye, Yerkes.

The Story of Cosmic Rays--II

By W. F. G. Swann, *Director*
Bartol Research Foundation, Franklin Institute

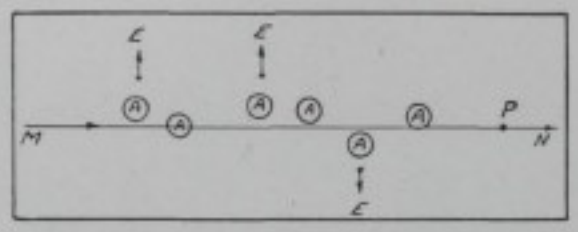
2. Further Properties of the Fundamental Particles

Ionization. Consider the behavior of a charged particle in creating ions as it passes through a gas. It detaches electrons from the atoms which it approaches sufficiently closely, and these electrons form the basis for the creation of ions, as we discussed last month. If the charged particle is moving very rapidly, with a speed comparable with but not too nearly equal to the velocity of light, and if it carries the equivalent of one electronic charge, it detaches from atoms about 30 electrons per centimeter of path at atmospheric pressure.

By this act, the particle loses energy as it progresses through the gas, and the more energy it has lost the more rapidly does it spend that which remains. I have likened the procedure to that of a bibulous individual who, starting with a certain amount of money in his pocket, visits every tenth saloon which he encounters. As his money disappears, he starts to visit every fifth saloon. Becoming more reckless with the diminution of his coins, he visits every second saloon, then every one, so that he finally ends up in an orgy of bankruptcy and disappears from the scene of visible activity.

Particles moving more nearly with the speed of light, that is, faster than those that begin by detaching about 30 electrons per centimeter of path, are even more active. Thus, the charged particle spends its energy freely when it is very rich (moving nearly with the speed of light) and when it is very poor (near the end of its path). It is most conservative in its expenditures when it is moderately rich.

The ionization produced by a particle per centimeter of its path depends to a first approximation only upon its velocity and its charge. Doubling the charge increases the ionization per centimeter of path by a factor of four.



P is a high-energy charged particle pursuing the line of flight MN. It affects atoms along its path and frees the electrons, E.

Pair Production. A phenomenon more drastic than ionization occurs when very rapidly moving charged particles collide with atoms, and associated with it is a phenomenon resulting from the collision of high-energy photons with atoms. The charged particles concerned in this matter are almost exclusively electrons, for although, in principle, heavier particles can operate in an analogous manner, the effect is so much more prominent in the case of the lighter electron that we can ignore it in the other cases.

Start with a high-energy photon which finds itself directed toward an atom. This photon possesses the characteristic of becoming mathematically irritated when it comes into the vicinity of the atom. Existence as a photon becomes mathematically intolerable, but nature has provided for it the option of changing its state of existence by allowing it to materialize into two oppositely charged electrons; these share the energy of the photon between them, but not necessarily in equal amount.

We may liken the above events to a spiritualistic séance, in which the photon is the ghost, the two electrons are the materialization of the ghost, and the atom is the medium. Nothing in particular happens to the medium, except that it gets what we may call an atomic fright, which is even symbolized in the mathematics by certain oscillations in the atom that prevail during the materialization and subside in due course after it is completed.

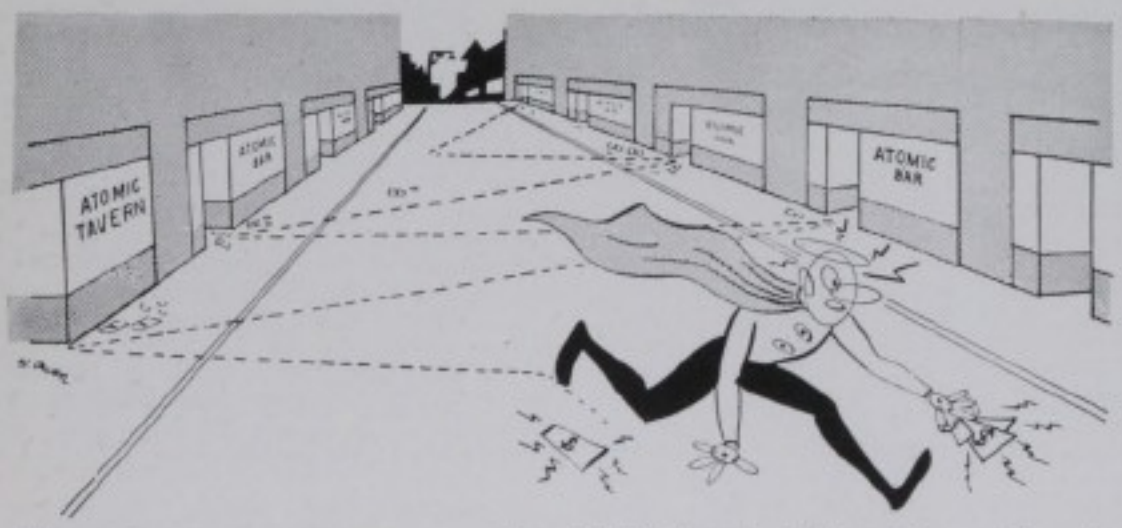
Each of the pair of electrons thus produced pursues its course, and if either has sufficient energy, when entering the domain of another atom it will jerk that atom in such a manner as to give rise to a new photon. This photon, if of sufficient energy, will repeat the history of its ancestors, giving rise to two more charged particles. The process would go on and on were it not for the fact that each of these progeny has only a small share of the energy of the original photon; and when the energy of a particle falls below about 10 million electron volts, the chance of it reproducing itself in this manner becomes infinitesimal. (An electron volt is the energy gained by an electron in falling through a drop of potential of one volt.)

Once the energy of an electron has fallen below the value necessary to carry on the process of photon emission and pair production, its remaining energy is gradually drained away from it by ionization and it loses the characteristics of a high-energy ray.

In the light of the foregoing, it may be expected that if a high-energy photon or electron enters our atmosphere, or comes into existence in the upper atmosphere as a result of the primary cosmic rays, this electron or photon will initiate the phenomenon of pair production. As we descend into the atmosphere, the number of electrons passing through a unit area will at first increase, attaining finally a maximum, after which it will decrease. This is because there is a birth rate of electrons resulting from the pair production and a death rate resulting from electrons falling to an energy at which they are no longer able to perpetuate the process. Highest in the atmosphere is a region where the birth rate exceeds the death rate; below that the two are equal and the number of rays is a maximum; further descent takes us to regions where the death rate exceeds the birth rate and the number of electrons diminishes.

As we proceed in the study of cosmic rays, we shall find that pair production plays a significant role in the phenomena observed.

Properties of Mesotrons. As already stated, the need for the existence of a charged particle intermediate in mass between the electron and the proton was



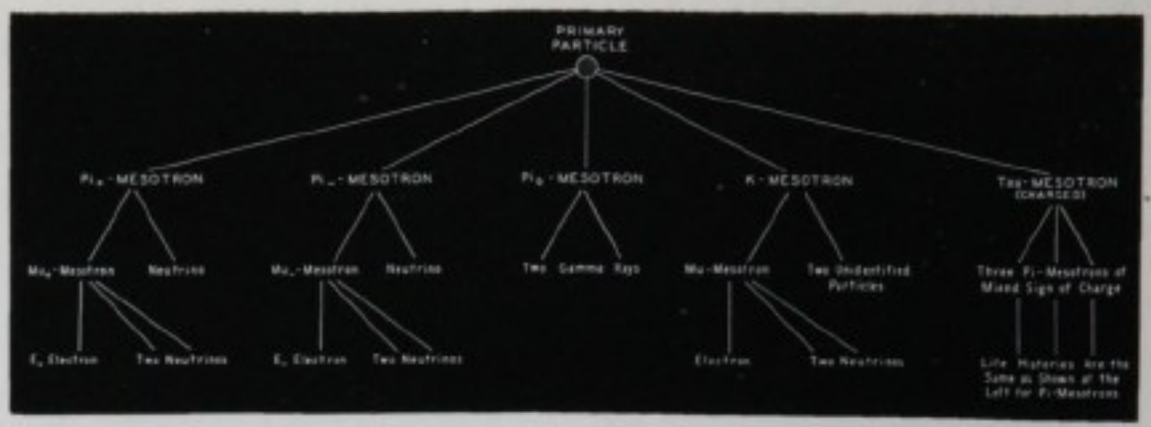
The adventures of a high-energy "particle." Reprinted from "Aero Digest."

first sensed by the Japanese physicist Yukawa, as a result of efforts to understand the nature of the forces that bind the particles of an atomic nucleus together. From purely theoretical considerations, Yukawa was able to calculate the mass and mean life of the particle in question: about 300 times the mass of the electron and a mean life of the order of 1/100 of a microsecond (a microsecond is a millionth of a second).

Not long after Yukawa's calculations were made, it was found that the principal constituents that we observe as cosmic rays at sea level are charged particles having a mass of the general order of magnitude of that of Yukawa's predictions, but these particles have a mean life of the order of 100 times that predicted by him.

Of course, the discrepancy of 100 times in the mean life was embarrassing to the logic of the subject, but physicists were happy to have experimental verification of Yukawa's work to the extent of the actual existence of any kind of particle intermediate in mass between the electron and the proton, and having any kind of a finite life expectancy. It was hoped that time would clear up the discrepancy, possibly by modifications of the theory.

Time did, indeed, clear up the discrepancy, but not quite in the way anticipated. The particle found in cosmic rays was not Yukawa's mesotron, but rather a child of that mesotron. Before very long, experiment revealed that there did indeed exist in nature a particle, now called the *pi-mesotron* (π-mesotron), of mass about 300 times the electron's mass and with a mean life of the order of a hundred millionth of a second, as predicted by Yukawa. The pi-mesotrons are



The descendants of a high-energy particle may include those shown here. Any one such primary particle does not, in general, give rise to all the types of mesotrons in the second stage.

usually brought into existence as the result of the bombardment of atomic nuclei by high-energy charged particles such as the primary cosmic rays which enter our atmosphere from outer space. This kind of mesotron can have either a positive or negative charge.

Experiment has further revealed the existence of uncharged mesotrons of mass about 300 electron units; these are also called pi-mesotrons. They are produced by bombardment of atomic nuclei by high-energy particles, and have a life expectancy of the order of 10^{-13} second. A neutral pi-mesotron decays into two photons of high energy—gamma rays.

The child of the pi-mesotron is called a *mu-mesotron* (μ-mesotron), and it is the result of the death of a pi-mesotron, which is thought to be accompanied also by the emission of a neutrino. The mu-mesotron plays the most important role in cosmic ray phenomena. Being a charged particle, it, of course, ionizes like any other charged particle. However, it has a rest mass 210 times as great as that of the electron, and so an energy 210 times that of the electron for the same velocity. Moreover, on account of its large mass, it is relieved of the duty of pair production and loses energy only by ionization phenomena. As a result of this, the mu-mesotron can travel very much farther through matter than can an electron of the same energy.

The mu-mesotron, when traveling with a velocity small compared with that of light, has an average life of only about 2.3 microseconds. Even if it traveled with the velocity of light and had only this average lifetime, it could not go more than about 700 meters before death overtook it. However, as already remarked, the theory of relativity demands and experiment confirms that the lifetime of the particle shall increase with its energy. As a result of this, many cosmic ray mesotrons have lives hundreds or thousands of times 2.3 microseconds, so that, so far as life is concerned, they could travel right through the atmosphere and to distances far below.

The death of a mu-mesotron is accompanied by the birth of an electron—positive or negative—and two neutrinos.

Finally, in the realm of cosmic ray particles there have appeared the *K-mesotron*, of around 1,100 electron mass units, and another heavy particle, the *tau-mesotron* (τ-mesotron) of about 900 electron mass units. The tau-mesotron is unstable and is believed to decay into three pi-mesotrons.

It is of interest to observe that even the neutron, when in free space, is unstable and has a life expectancy of only about 18½ minutes, after which it changes to a proton by ejecting an electron in the mysterious process aforesaid—that of dividing nothing into two halves, throwing out the negative half (a negative electron) and retaining the positive half (a proton).

Of the various mesotrons, only the mu-mesotron plays a significant part in the phenomena observed in cosmic rays. However, from the standpoint of what one may call cosmic ray genealogy, a recognition and understanding of the other particles that we have described is necessary.

(To be continued)

Elementary Particles of Matter

Particle	*Mass in electron masses*	*Average lifetime against spontaneous decay*	*Products of spontaneous decay**
Electron	1	Stable	.....
Proton	1,845	Stable	.....
Neutron	1,848	18.5 ± 3.6 minutes	Proton and electron
Positron	1	Stable	.....
Positive mu-mesotron	210	2.3×10^{-6} sec.	Electron and two neutrinos
Negative mu-mesotron	210	2.3×10^{-6} sec.	Electron and two neutrinos
Positive pi-mesotron	276	About 10^{-8} sec.	Mu-mesotron and neutrino
Negative pi-mesotron	276	About 10^{-8} sec.	Mu-mesotron and neutrino
Neutral pi-mesotron	264	Less than 10^{-13} sec.	Two photons
K-particle	About 1,100	About 10^{-9} sec.	One mu-mesotron and two neutral particles
Tau-particle	977	Greater than 10^{-9} sec.	Three pi-mesotrons
Chi-mesotron†	900-1,500	Greater than 10^{-9} sec.	Pi-mesotron and one neutral particle
Kappa-mesotron†	Less than 1,400	Greater than 10^{-9} sec.	Mu-mesotron
Zeta-particle	537	Greater than 10^{-10} sec.	Two pi-mesotrons
Positive V-particle†	Uncertain	Less than 10^{-9} sec.	Uncertain
Negative V-particle†	Uncertain	Less than 10^{-9} sec.	Uncertain
Neutral V-particle	Uncertain	Less than 10^{-10} sec.	Probably mesotrons and protons
Photon	0	Stable	None
Neutrino	0	Stable	None

*In general, these products are accompanied with release of energy in kinetic form and in amount sufficient to conserve mass.

†It is uncertain how far the positive and negative V-particles are distinct from the chi- and the kappa-particles.

NEWS NOTES

By Dorrit Hoffleit

POSSIBLE FLARE STAR

D. M. Popper, of the University of California at Los Angeles, in the December *Publications* of the Astronomical Society of the Pacific, reports a possible new flare star, HD 234677, magnitude 8.3, whose 1950 position is $18^h\ 32^m.8$, $+51°\ 41'$. The spectral class of this dwarf, variously published between *K*5 and *M*1, is earlier than for most flare stars. Its absolute magnitude has been estimated as about +8.0, several magnitudes brighter than the recognized flare stars. Nevertheless, the star has flare characteristics.

The behavior of its hydrogen emission lines is similar to that during flares in the stars L726-8 and Proxima Centauri. Thus HD 234677, too, may be a flare star. If so, however, the variations in apparent magnitude would be less conspicuous than in the other less luminous members of the class. This star might be a worthwhile object for amateurs with photoelectric equipment.

GROWTH BY ACCRETION

W. H. McCrea, of Cambridge, England, has discussed how the theory of accretion can account for the most luminous stars, in a recent issue of the *Monthly Notices* of the Royal Astronomical Society. These stars, according to accepted ideas on energy generation, can maintain their observed luminosities for only a small fraction of the lifetime of our galaxy. But their present existence could be explained by a sufficiently high rate of accretion of hydrogen from interstellar space. The theory must not only account for the growth of these stars to their present large masses, but must also provide hydrogen at a rate sufficient to compensate for its consumption in the stars.

The concept of accretion is not new, but it has in the past met serious objection. This is because it seems to require a very slowly moving star passing through an exceptionally large and dense interstellar cloud — an extremely unlikely combination of circumstances. Dr. McCrea, however, argues that the entire problem is to account for exceptional stars, representing perhaps one in a million. Hence the conditions required are not so unlikely, relatively speaking, as was previously thought.

He supports this argument by calculations more refined than heretofore, which indicate increased efficiency of the accretion process. Of particular importance is the fact that a sufficiently dense cloud can bring stars of two to five solar masses to rest within it. He finds that, even at the lowest rates of accretion, the *O* stars must have acquired most of their mass within the last 10^8 years. The accretion is then more than enough to compensate for the hydrogen consumption in the star. Stars with twice the sun's mass can maintain their luminosity for the past lifetime of the galaxy, while stars now more massive must have grown by accretion.

As an illustration, Dr. McCrea considers a hypothetical binary with an initial mass for each component of twice that of the sun, entering a cloud of density 5×10^{-21} grams per cubic centimeter, with gas kinetic temperature of 50° absolute. The initial speed of the system relative to the cloud is assumed to be 1.5 kilometers per second. He shows that the star would be stopped within four parsecs and would acquire a very large mass in five million years. Older and simpler formulae would require 20 times the distance and 10 times as long an accretion period.

Summarizing, Dr. McCrea states that stars of large mass are formed from less massive ones by the accretion process. "The mechanism is simply that the interstellar material halts the motion of the star through it and then falls into the star."

AE AURIGAE

Long known as a 6th-magnitude irregular variable star of small amplitude, AE Aurigae belongs to the uncommon spectral class *o*9.5 V, which designates a hot blue dwarf star. Its distance is about 500 parsecs. This star has attracted further attention by its space velocity of 128 kilometers per second, unusually high for its spectral class. Moreover, it is embedded in the diffuse nebula IC 405, a bright and peculiarly shaped H-II region. This shape is like that of a figure 7, whose crossbar is a bright, irregular oval about 18 minutes of arc (2.8 parsecs) across, and whose tail is a faint nebulous streamer, pointing away from the direction in which the star is moving. This remarkable nebula and star are the subject of a recent stimulating discussion by A. Blaauw, of Leiden University, and W. W. Morgan, of Yerkes Observatory, in *Bulletin 448* of the Astronomical Institutes of the Netherlands.

The nebula IC 405 is shown here as photographed in hydrogen-alpha light by Shajn and Hase. The circle marks the location of the star AE Aurigae, whose motion is upward in this picture. The picture gives the impression that the dense oval patch of nebulosity, moving with the star, has swept up the interstellar material in its path, leaving the matter to the right of the sharp vertical edge in its original position. From the "Bulletin" of the Astronomical Institutes of the Netherlands.

The space motion of the star, which appears to be shared by the nebula, is directly away from the Orion nebula, more than 30 degrees away on the sky. It is possible that the nebula might have once formed a part of the Orion nebula, being expelled from it about 2,700,000 years ago. The authors suggest that IC 405 is the nebula out of which the star AE Aurigae has since condensed; thus, the star must be younger than the nebula, perhaps only one or two million years old. For if the star had been born at the time of the supposed expulsion of the nebula from Orion, the nebula should have lagged behind the star on passing through any obstructing matter; this has apparently not been the case.

Drs. Blaauw and Morgan, following theories by Oort and Spitzer, explain the ejection of the nebula from Orion as due to the one-sided ionization of the cloud by hot stars in Orion; the effect is like that of a jet from a rocket, where reaction forces the rocket forward. Strong compression in the non-ionized parts of the cloud, a likely result of the expulsion, would then favor the formation of a massive star or stars sharing the motion of the cloud.

IN THE CURRENT JOURNALS

THE POCKET NAUTICAL ALMANAC, by Paul E. Wylie, **Navigation,** December, 1953. "What does appear now, because of the bulk and the cost of the current **American Nautical Almanac,** is that the time is ripe for the publication of an accurate, cheap, compact almanac for American circulation, for the benefit of certain classes of users, and for the benefit of all classes in certain emergencies."

THE ORIGIN OF STARS AND GALAXIES, by D. ter Haar, **Scientific Monthly,** December, 1953. ". . . there have been lately a number of attempts to produce a general cosmogony and . . . probably von Weizsaecker's ideas have the best chance to lead to a more detailed understanding of the formation and evolution of stars and galaxies."

BETA CANIS MAJORIS STARS

Stars of the Beta Canis Majoris group are early *B*-type variables, with ranges not more than a few tenths of a magnitude. Their periods, easily determined from the variation in radial velocity, are mostly between three and six hours. Two recent papers report independent discoveries that these stars have a period-luminosity relationship, analogous to that for the classical Cepheids.

In the *Publications* of the Astronomical Society of the Pacific, D. H. McNamara, at the University of California, points out that his earlier discovery of a period-spectrum relation also implies a period-luminosity relation. He lists 10 stars with periods between 3.6 and 6.0 hours, whose spectra indicate absolute magnitudes ranging from −4.7 to −3.0. Arranging these stars in order of increasing period puts them in order of increasing luminosity. When their absolute magnitudes and spectral types are plotted in an H-R diagram, the Beta Canis Majoris stars form a steep band lying above the main sequence, appearing to join it at *B*3.

The other discovery of the period-luminosity relation is by A. Blaauw and M. P. Savedoff, at Leiden, reported in the *Bulletin* of the Astronomical Institutes of the Netherlands. Working with only six stars, they find a similar connection between absolute magnitude and period.

UTAH CRATERS MAN-MADE

In October, 1952, *Sky and Telescope* carried an article by Dr. Richard N. Thomas, then of the University of Utah and Harvard Observatory, entitled, "Four Possible Meteorite Craters in Utah." This described small depressions in a rock wash that might have been explained by the impact of meteorites. The following letter has now been received (in answer to an inquiry) from Mrs. Van Wiley, of Antimony, Utah, which definitely eliminates the meteoritic possibility and explains the man-made origin of these craters:

"In regard to the crater[s] some miles below here, my husband had about 25 cases of old dynamite which he and another farmer had purchased to use in making a drain ditch through a piece of swamp ground in their adjoining pastures. They had a large ditcher dig the drain, so the powder wasn't used and set here several years until it was too dangerous to use.

"They carefully loaded and hauled the 25 cases quite a ways from any house or person and stacked [them] on this hillside, and then, using a 270 rifle, they fired into it discharging all of the dynamite. I think they had either two or three different piles. Of course, this caused all the brush, etc., to be burned off this hillside and the small crater-like holes."

Observing the Messier Catalogue

By Owen Gingerich, *Harvard College Observatory*

THE OBSERVING repertoire of a great many amateurs is, unfortunately, limited to the moon, planets, Orion nebula, Andromeda galaxy, Hercules cluster, and a few other choice favorites. These are splendid sights, well worth observing. Many other worthwhile celestial objects, however, can be seen with a telescope of 6- or 8-inch aperture. The brightest of these may be found in the Messier catalogue, which is published as part of this article, together with a key chart, on pages 158 and 159.

Of the nearly 100 items in the original catalogue, 11 are nebulae and the others are divided about evenly among galaxies, globular clusters, and galactic clusters. They range from 70 degrees north to 35 degrees south declination. At least a score of them can be seen at any time, but the selection of some of each type may not always be possible, since for evening observing most of the galaxies are best placed in the spring, the globular clusters in summer, and the galactic clusters in the fall and winter skies of the Northern Hemisphere.

Most of the galaxies are rather inconspicuous, and a dark night is necessary for success. Many telescope owners have located the Andromeda spiral, M31, and have picked out the associated galaxies in the same field, M32 and NGC 205. Fewer have found the widely illustrated M33 in nearby Triangulum. A perfect night and low power are required for this giant. Like the other spirals, it appears as a faint patch of light without detail, but much larger than most because it is one of the nearest, 1,500,000 light-years away.

Those seeking an unusual spiral system should be able to locate M51 without much difficulty; it is the Whirlpool nebula in Canes Venatici, whose irregular companion *appears* to be whirling out from the main spiral. Its distance of about six million light-years (on the basis of doubling the earlier value) places it midway among Messier's spirals. In a 6-inch telescope, both M51 and its irregular companion are readily discernible.

The most distant Messier galaxies are 15 members of the Coma-Virgo cluster, all about 16 million light-years away. Only with an atlas can they be identified with certainty; they are included in the lists and charts of Deep-Sky Wonders for the Coma-Virgo region published in *Sky and Telescope* for May and June, 1949.

M64 will please those looking for a brighter galaxy after viewing the faint specks of the main Coma-Virgo hunting ground. This galaxy, sometimes called the Black-eye nebula, can be found near the star 35 Comae Berenicis.

The two northernmost Messier objects, M81 and M82, are galaxies that will usually impress visitors. The first is spiral, while M82 is a bright irregular system. With a rather low power, both may be maneuvered into the same field. The distance of M81 has recently been established at seven million light-years.

As summer approaches, northern observers replace low powers with high in order to resolve some of the score of globular clusters Messier charted in summer evening skies. Most amateurs have examined M13, the great cluster in Hercules which may be seen with the naked eye. Many are not aware that M4 in Scorpius, M22 in Sagittarius, and some of the Ophiuchus globulars are actually easier to resolve. Two forerunners of the main group of summer globulars give pleasant variety to spring observing: M3 in Canes Venatici, and M53 in Coma Berenices.

Messier's open clusters are concentrated along the Milky Way and are therefore almost absent in the spring when it lies along the horizon. Some Messier clusters resemble random patches of Milky Way so much that identification becomes confusing, but M6 and M7, though deep in the Scorpius star-clouds, are striking enough for recognition. A fine field of stars such as these, or M44, Praesepe in Cancer, seldom fails to be impressive with low powers.

Much variety is found among the clusters. A triplet in Auriga illustrates this: M36 and M38 are coarse clusters, while M37 appears as a fine pepper-shaker grouping. M35, which lies in Gemini nearby, fits midway in the scale. In Scutum, M11 is a fine fan-shaped selection which shows to best advantage under somewhat higher powers.

The diffuse and planetary nebulae are perhaps the most interesting of all, partly because they are rare, but mostly because an amateur telescope will show some detail. Traces of rifts and arms become visible in the Trifid nebula, M20, in a 6- or 8-inch instrument, although the division into three parts does not show. One of the few Messier objects associated with another, M20 joins the delicate open cluster M21.

Not too much imagination is needed to discover the shape of the Horseshoe or Omega nebula, M17, in Sagittarius. Near the foot of the Northern Cross is M27, the Dumbbell nebula; the notches in this round patch should be evident in a good telescope. This planetary is larger and brighter than M57, the famed Ring nebula in nearby Lyra, yet it is not observed nearly as often. In Taurus,

M1, the Crab nebula, which led Messier to compile his catalogue, is for the hale and hearty who brave the winter weather. Its pseudoplanetary appearance makes it an interesting object. In the same region of the sky, M42 and M43, both numbers referring to parts of the Orion nebula, are usually well observed.

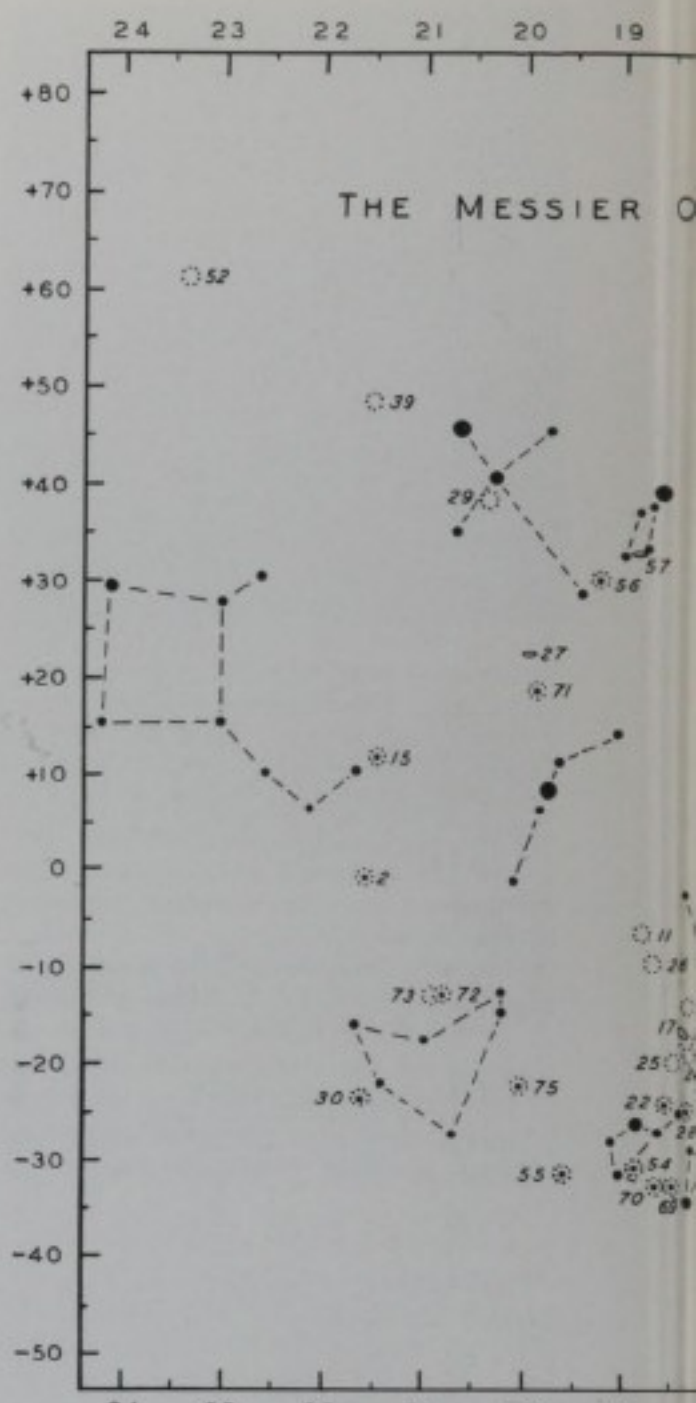
Most of the Messier objects are plotted in Norton's and the Skalnate Pleso atlases; either of these is helpful and sometimes necessary for locating a particular object. For telescopes with circles, however, the positions in the accompanying catalogue should suffice.

As described in my article in *Sky and Telescope*, August and September, 1953, from the historical standpoint the Messier catalogue should be divided into parts, by object number, as follows:

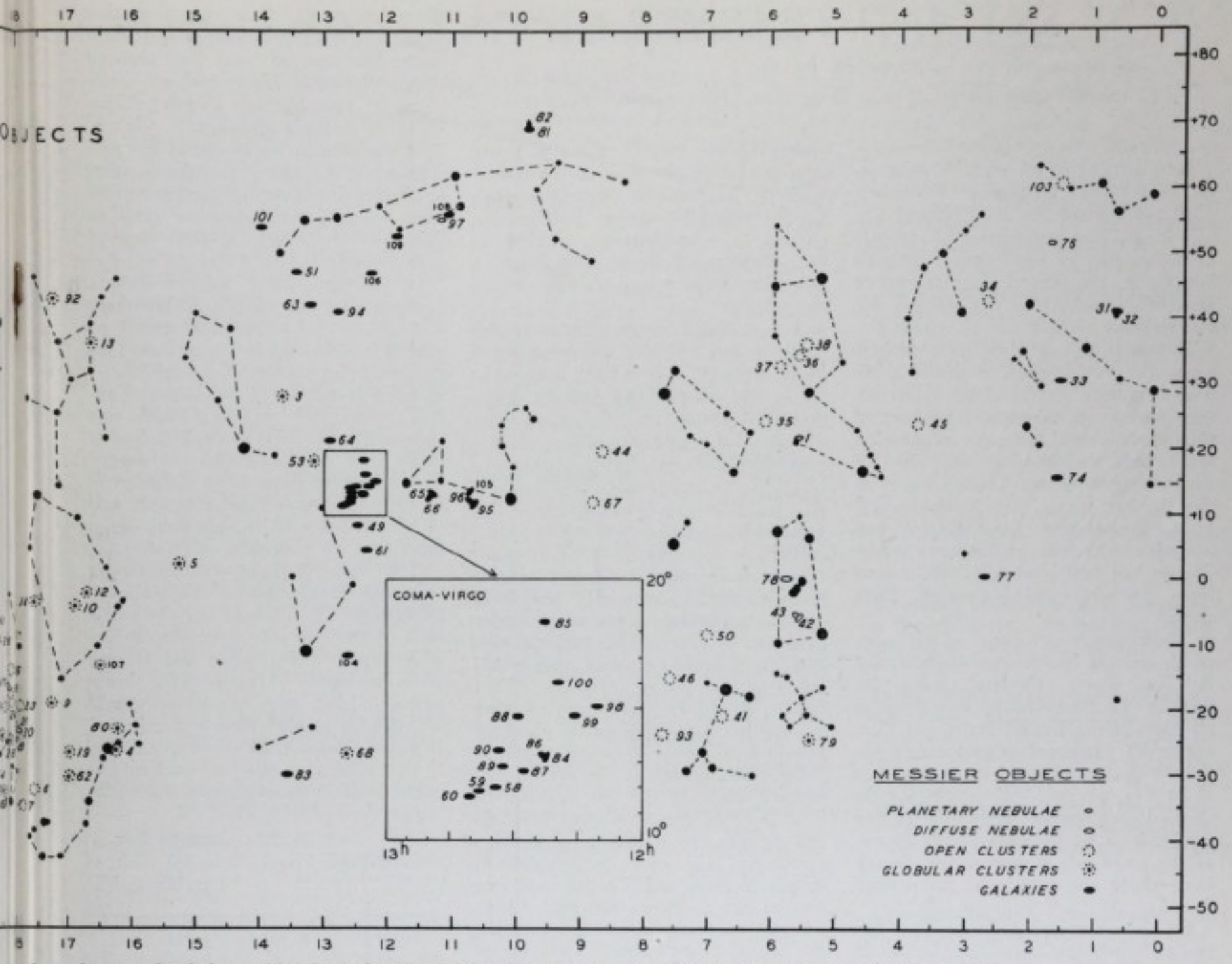
1-45	First list from the *Histoire de l' Académie Royale des Sciences* for 1771
46-68	Additional objects first published in the *Connaissance des Temps* for 1781
69-103	Additional objects first published in the *Connaissance des Temps* for 1784
104-109	Objects reported by Méchain in the *Berliner Astronomisches Jahrbuch* for 1786

The Messier Catalogue

M	*NGC*	*R.A.* h m(1950)	*Dec.* ° ′	*Const.*	*Size* ′ × ′	*Mag.*	*Type*
1	1952	05 31.5	+21 59	Tau	6 x 4	10	Pl—Crab nebula
2	7089	21 30.9	−01 03	Aqr	12	7	Gb
3	5272	13 39.9	+28 38	CVn	19	6	Gb
4	6121	16 20.6	−26 24	Sco	23	6	Gb
5	5904	15 16.0	+02 16	Ser	20	6	Gb
6	6405	17 36.7	−32 11	Sco	26	6	Cl
7	6475	17 50.6	−34 48	Sco	50	5	Cl
8	6523	18 00.7	−24 23	Sgr	90 x 40		Di—Lagoon nebula
9	6333	17 16.2	−18 28	Oph	6	7	Gb
10	6254	16 54.5	−04 02	Oph	12	7	Gb
11	6705	18 48.4	−06 20	Sct	12	6	Cl
12	6218	16 44.6	−01 52	Oph	12	7	Gb
13	6205	16 39.9	+36 33	Her	23	6	Gb—Hercules cluster
14	6402	17 35.0	−03 13	Oph	7	8	Gb
15	7078	21 27.6	+11 57	Peg	12	6	Gb
16	6611	18 16.0	−13 48	Ser	8	7	Cl
17	6618	18 17.9	−16 12	Sgr	46 x 37		Di—Omega or Horseshoe nebula
18	6613	18 17.0	−17 09	Sgr	7	7	Cl
19	6273	16 59.5	−26 11	Oph	5	7	Gb
20	6514	17 59.6	−23 02	Sgr	29 x 27		Di—Trifid nebula
21	6531	18 01.6	−22 30	Sgr	12	7	Cl
22	6656	18 33.3	−23 58	Sgr	17	6	Gb
23	6494	17 53.9	−19 01	Sgr	27	7	Cl
24	6603	18 15.5	−18 26	Sgr	4	6	Cl
25		18 28.8	−19 17	Sgr	35		Cl—IC 4725
26	6694	18 42.5	−09 27	Sct	9	8	Cl
27	6853	19 57.5	+22 35	Vul	8 x 4	8	Pl—Dumbbell nebula
28	6626	18 21.5	−24 54	Sgr	15	8	Gb
29	6913	20 22.1	+38 22	Cyg	7	7	Cl
30	7099	21 37.5	−23 25	Cap	9	8	Gb
31	224	00 40.0	+41 00	And	160 x 40	4	Sp—Andromeda nebula
32	221	00 40.0	+40 36	And	3 x 2	9	El
33	598	01 31.1	+30 24	Tri	60 x 40	7	Sp
34	1039	02 38.8	+42 34	Per	30	6	Cl
35	2168	06 05.8	+24 21	Gem	29	6	Cl
36	1960	05 32.8	+34 06	Aur	16	6	Cl
37	2099	05 49.1	+32 32	Aur	24	6	Cl
38	1912	05 25.3	+35 48	Aur	18	7	Cl
39	7092	21 30.4	+48 13	Cyg	32	6	Cl
40							
41	2287	06 44.9	−20 41	CMa	32	6	Cl
42	1976	05 32.9	−05 25	Ori	66 x 60		Di—Great Nebula in Orion
43	1982	05 33.1	−05 18	Ori			Di—(NE wing of Great Nebula)
44	2632	08 37.2	+20 10	Cnc	90		Cl—Praesepe or the Beehive
45		03 44.5	+23 57	Tau	120		Cl—Pleiades
46	2437	07 39.6	−14 42	Pup	27	9	Cl
47							
48							
49	4472	12 27.3	+08 16	Vir	4 x 4	9	El
50	2323	07 00.6	−08 16	Mon	16	6	Cl
51	5194-5	13 27.8	+47 27	CVn	12 x 6	9	Sp—Whirlpool nebula
52	7654	23 22.0	+61 19	Cas	13	7	Cl
53	5024	13 10.5	+18 26	Com	14	8	Gb
54	6715	18 52.0	−30 32	Sgr	6	8	Gb
55	6809	19 36.9	−31 03	Sgr	15	5	Gb



M	*NGC*	*R.A.* h m(1950)	*Dec.* ° ′	*Const.*	*Size* ′ × ′	*Ma*
56	6779	19 14.6	+30 05	Lyr	5	
57	6720	18 51.8	+32 58	Lyr	1 x 1	
58	4579	12 35.1	+12 05	Vir	4 x 3	1
59	4621	12 39.5	+11 55	Vir	3 x 2	1
60	4649	12 41.1	+11 49	Vir	4 x 3	1
61	4303	12 19.4	+04 45	Vir	6 x 6	1
62	6266	16 58.1	−30 03	Oph	6	
63	5055	13 13.5	+42 17	CVn	8 x 3	1
64	4826	12 54.3	+21 57	Com	8 x 4	
65	3623	11 16.3	+13 23	Leo	8 x 2	1
66	3627	11 17.6	+13 17	Leo	8 x 2	
67	2682	08 48.5	+12 00	Cnc	18	
68	4590	12 36.8	−26 29	Hya	9	
69	6637	18 28.1	−32 23	Sgr	4	
70	6681	18 40.0	−32 21	Sgr	4	
71	6838	19 51.5	+18 39	Sge	6	
72	6981	20 50.7	−12 44	Aqr	5	
73	6994	20 56.2	−12 50	Aqr		
74	628	01 34.0	+15 32	Psc	8 x 8	1
75	6864	20 03.2	−22 04	Sgr	5	
76	650-1	01 39.1	+51 19	Per	2 x 1	1
77	1068	02 40.1	−00 14	Cet	2 x 2	
78	2068	05 44.2	+00 02	Ori	8 x 6	
79	1904	05 22.2	−24 34	Lep	8	
80	6093	16 14.1	−22 52	Sco	5	
81	3031	09 51.5	+69 18	UMa	16 x 10	
82	3034	09 51.9	+69 56	UMa	7 x 2	



ers have been omitted from this chart, for simplicity. The key matches that of our regular monthly star charts.

Key	Type	M	NGC	R.A. h m(1950)	Dec. ° ′	Const.	Size ′ ′	Mag.	Type
1	Gb	83	5236	13 34.3	−29 37	Hya	10 x 8	9	Sp
2	Pl—Ring nebula	84	4374	12 22.6	+13 10	Vir	3 x 3	10	El
3	Sp	85	4382	12 22.8	+18 28	Com	4 x 2	10	El
4	El	86	4406	12 23.7	+13 13	Vir	4 x 3	10	El
5	El	87	4486	12 28.3	+12 40	Vir	3 x 3	10	El
6	Sp	88	4501	12 29.5	+14 42	Com	6 x 3	10	Sp
7	Gb	89	4552	12 33.1	+12 50	Vir	2 x 2	11	El
8	Sp	90	4569	12 34.3	+13 26	Vir	6 x 3	11	Sp
9	Sp—Black-eye nebula	91							
10	Sp	92	6341	17 15.6	+43 12	Her	12	6	Gb
11	Sp	93	2447	07 42.5	−23 45	Pup	18	6	Cl
12	Cl	94	4736	12 48.6	+41 23	CVn	5 x 4	8	Sp
13	Gb	95	3351	10 41.3	+11 58	Leo	3 x 3	11	Sp
14	Gb	96	3368	10 44.2	+12 05	Leo	7 x 4	10	Sp
15	Gb	97	3587	11 11.9	+55 18	UMa	3 x 3	11	Pl—Owl nebula
16	Gb	98	4192	12 11.3	+15 11	Com	8 x 2	11	Sp
17	Gb	99	4254	12 16.3	+14 42	Com	4 x 4	10	Sp
18	(Only 4 stars)	100	4321	12 20.4	+16 06	Com	5 x 5	10	Sp
19	Sp	101	5457	14 01.4	+54 35	UMa	22 x 22	8	Sp
20	Gb	102							
21	Pl	103	581	01 29.9	+60 26	Cas	6	7	Cl
22	Sp	104	4594	12 37.3	−11 21	Vir	7 x 2	8	Sp—Sombrero nebula
23	Di	105	3379	10 45.2	+12 51	Leo	2 x 2	10	El
24	Gb	106	4258	12 16.5	+47 35	CVn	20 x 6	10	Sp
25	Gb	107	6171	16 29.7	−12 57	Oph	8	9	Gb
26	Sp	108	3556	11 08.7	+55 57	UMa	8 x 2	10	Sp
27	Ir	109	3992	11 55.0	+53 39	UMa	7	11	Sp

ABOUT THE CATALOGUE

The numbers with blank lines are the "errors or mysteries" described by Mr. Gingerich in his articles last August and September.

The positions are for 1950, and constellations are according to the IAU boundaries. Sizes have been rounded to the nearest minute of arc. Magnitudes are approximate visual; for globulars and clusters, they are rounded from M. Nabokov's list in "Astronomische Nachrichten," 241, Whole Number 5777, 1931; for galaxies, integrated photographic magnitudes were raised 0.6 magnitude and then rounded; for planetaries, the magnitudes were supplied by Mr. Gingerich.

Types of clusters are: *Cl*, open or galactic, from R. J. Trumpler, Lick Observatory "Bulletin," 420, 1930. *Gb*, globular, from Helen B. Sawyer, David Dunlap Observatory "Publications," 1, No. 20, 1947.

Types of nebulae are: *Di*, diffuse, from S. Cederblad, Lund Astronomical Observatory "Meddelande," Series II, No. 119, 1946. *Pl*, planetary, from H. D. Curtis, Lick Observatory "Publications," XIII, Part III, 1918.

Types of galaxies are: *El*, elliptical; *Ir*, irregular; *Sp*, spiral; from Shapley-Ames, Harvard Observatory "Annals," 88, No. 2, 1932.

CORRECTION

On page 291, column 1, of the September, 1953, issue, the missing Messier objects should read, "M40, M47, M48, M91, M102 . . ."

☆ ☆ SKY AND TEACHER ☆ ☆

Sponsored by the
Teachers' Committee of the American Astronomical Society

One Hundred and One Astronomers

At a meeting of the teachers' committee at Amherst College in December, 1952, we learned that the National Science Foundation was interested not only in the support of astronomical research but also in the general improvement of astronomy teaching in the colleges and universities.

In order to formulate some definite proposals, we felt that we should know how important the teaching of astronomy was to astronomers. As part of this study some accurate information was needed concerning recipients of Ph.D. degrees in the United States in the postwar years. On September 17, 1953, a one-page questionnaire was mailed to the 101 astronomers whose degrees had been received in the interval from January, 1945, through June, 1953.

These people are now widely scattered, and the letters went to Australia, Belgium, Egypt, England, India, Indonesia, the Netherlands, as well as to all parts of the United States and Canada. We attempted to gauge our questions so that they could be answered in about five minutes. We appreciate the unusual co-operation received — we had replies from 93 per cent of the group; of the seven whose answers we do not have, three are outside of the United States.

Of those answering, 86 per cent had received their undergraduate degrees in this country, from institutions varying greatly in type and size as well as in geographical location. Represented by a single student were Arizona, Augustana, Boston College, Boston University, Brown, Carleton, Case, College of the City of New York, Denver, Drake, Drexel, Hamilton, Illinois, Indiana, Iowa State, Johns Hopkins, Kansas, Kentucky, Minnesota, Missouri, Park, Pennsylvania, Princeton, Radcliffe, South Carolina, Vassar, Virginia, Wisconsin, and Wooster. Brooklyn, Cincinnati, Northwestern, Ohio State, Smith, and Wellesley each provided two of the group, while Dartmouth, Michigan, Swarthmore, and the University of California at Los Angeles each had three graduates. The University of California and Harvard had eight each and Chicago was represented by 12 undergraduate degrees.

Of these 42 colleges and universities, only 10 have astronomy departments which give graduate work through the Ph.D. degree. Those whose undergraduate and Ph.D. degrees came from the same institution totaled 25, but only 11 of these listed astronomy as their undergraduate major. For the group as a whole 32 per cent of the undergraduates majored in astronomy while 52 per cent had either mathematics, physics, or a combination of these as their major. Of the 94 who answered there were four whose training was in engineering.

The graduate degrees show much less range, as seen from the following list of Ph.D. degrees in astronomy granted in the United States, from January, 1945, through June, 1953:

Chicago	25	Columbia	3
Harvard-Radcliffe	22	Iowa	3
California	16	Pennsylvania	3
Michigan	9	Yale	3
Princeton	6	Virginia	2
Georgetown	4	Northwestern	1
Caltech	3	Wisconsin	1

One of the questions asked whether their interest in astronomy had developed in pre-college years, as an undergraduate, or later. The replies showed that 60, 26, and 14 per cent, respectively, fell into these three intervals. These results should be heartening to those astronomers connected with planetariums or with groups of young people.

Of most interest is the use of their training made by the 101 astronomers. The last two questions asked the titles and locations of astronomical positions previously held, with approximate intervals of time, and the title and location of the positions now held (astronomical or otherwise). In evaluating the answers, we excluded graduate assistantships in research or teaching at the institution from which each degree was obtained. The present positions may be divided into three groups:

A. With teaching rank at universities or colleges: professor, 5; associate professor, 4; assistant professor, 25; lecturer or instructor, 10. Total, 44.

B. All research: at observatories, 22. As physicists or mathematicians, with university or educational connection, 9; with industries, 4; with the government, 8. Total, 43.

C. Others: in armed forces, 1; housewife, 5; theological student, 1. Total, 7.

Of group *A*, 89 per cent were teaching at least one class in astronomy, at 33 different colleges or universities, 30 of them in the United States. Of the other two groups, 72 per cent had done no college teaching.

Nine of the 15 women in the group are married and, of those, three continue with teaching or research in connection with a university, and one is a research physicist. Five of the 15 are included in group *A*.

Many times we have heard generalizations about the trend from teaching toward research. It is interesting that only 10 per cent of this group had taught more than one year and then changed completely away from teaching, while three per cent had left all-research positions to do some teaching.

It was pointed out by one of our participants in the survey that the question of impending military service has had an effect on long-term plans for some of those who had received their degrees most recently.

In the letter that went with our questionnaire, we mentioned that there was an indication that the supply of qualified teachers of astronomy was limited and suggested that this might mean an underproduction of astronomers. Several replies did not agree with this statement. For well-established departments with equipment that any one of us would like, there is no difficulty in filling vacancies as they occur. It was to institutions with less adequate equipment that the statement referred.

This report is closed with some questions that may stimulate further work along these lines: Could not the whole field of astronomy be strengthened if a wider basis of instruction and interest were developed? Do you think that a course in descriptive astronomy should be available in all liberal arts colleges? If so, what should be our responsibility in the training of qualified teachers and in the general improvement of the teaching of astronomy?

A. Marguerite Risley
Randolph-Macon Woman's College
Lynchburg, Va.

COMET CATALOGUES

In News Notes in the April, 1951, issue was noted a list of comets prepared by F. Baldet, printed in Paris. Now, Dr. Baldet and Miss G. de Obaldia have prepared a catalogue of comet orbits from 467 B.C. to A.D. 1952, a publication of the Meudon section of the Paris Observatory. The total number of cometary apparitions up to 1952 is 1,647, for 763 of which orbits have been calculated. The latter number includes 222 returns of periodic comets; thus, orbits of 541 different comets are known.

Another catalogue of comet orbits has appeared in *Acta Astronomica*, published at Cracow, Poland. In it Jiri Bouska, of Prague, extends the 1936 catalogue of the Japanese astronomer A. S. Yamamoto. Bouska and Yamamoto cite elements for 742 comets (including 99 discovered between 1936 and 1949), representing 525 separate comets.

Bouska further lists all comets observed at more than one return to perihelion, a total of 45. Of these, 27 belong to Jupiter's family, five to Saturn's, one to Uranus', and eight to Neptune's.

Amateur Astronomers

Anniversaries in New York and Argentina

THIS YEAR the Junior Astronomy Club is celebrating its 25th anniversary. Its first meeting was held in the American Museum of Natural History, in New York City, on April 26, 1929. From an original membership of 106, through our record enrollment of over 1,600 members, the club has maintained an average membership of about 500.

The society consists mostly of boys and girls of high school age and younger, although there are quite a few adults in the organization. The regularly scheduled monthly meetings include one each year, known as the Junior Competition, when several members deliver short talks. Saturday afternoon classes, taught by older members, are held in the club office.

On the first Saturday of each month, observing meeetings are held at Mosholu golf course, in the Bronx. Additional meetings are scheduled during the summer, and at other times smaller groups meet in various localities for observing.

The *Junior Astronomy News*, written and edited by club members, has been produced since 1929.

Junior Astronomy Club offices are now located in the Brooklyn Public Library, Grand Army Plaza, Brooklyn 38, N. Y., and lecture meetings are held there also.

Albert R. Hinn
and Stephen P. Maran
Junior Astronomy Club

The amateur astronomical society of Argentina, "Amigos de la Astronomia," has reached its 25th year. The organization was founded on January 4, 1929. Since then, it has spread knowledge of astronomy to the Argentine public by means of lectures, observation parties, and two astronomical shows. A third exhibit, to commemorate the 25th anniversary, will be held at the association headquarters, April 17-30.

The society has its own building (described in *Sky and Telescope*, December, 1944), with an observatory housing an 8½-inch refractor, and many smaller telescopes. There is a library, lecture room, classroom, laboratory, and a workshop for telescope makers.

Carlos L. Segers, secretary
Amigos de la Astronomia
Av. Patricias Argentinas 550
Buenos Aires, Argentina

COLUMBUS SOCIETY CONDUCTS PUBLIC NIGHTS

The Columbus Astronomical Society has had the responsibility of operating guest nights at the McMillin Observatory, Ohio State University, throughout 1953. This endeavor has been a great experience in many ways, and has added a number of new members to our group. We are glad that our efforts have been successful, and that we will continue the work for 1954. Perhaps other groups can have a similar opportunity.

These public nights are on the first and third Saturdays of every month, except July and August, at 7:30 p.m.

FRANK P. HUDNALL, president
Columbus Astronomical Society
McMillin Observatory
Columbus 10, Ohio

MIDDLE EAST CONVENTION

The Middle East region of the Astronomical League will hold its convention on May 28-30 in Pittsburgh, Pa., at the Buhl Planetarium and Institute of Popular Science, Federal and West Ohio Sts. The Amateur Astronomers Association of Pittsburgh, host society, will celebrate its 25th anniversary in conjunction with the convention.

Registration will open Friday evening, May 28th, followed by a planetarium sky show at 8:30 p.m. Saturday's sessions will be followed by a banquet in the Roosevelt Hotel ballroom, with a visit to Allegheny Observatory later. On Sunday there will be a possible trip to an optical shop in the Pittsburgh vicinity. Tentative plans include an instrument exhibit, and discussion of the total solar eclipse and the general convention following it.

The Roosevelt Hotel, a short walk from the planetarium, has been selected for hotel headquarters. All reservations are to be made directly by the individuals concerned. Adam L. Ott, Jr., is convention chairman, and may be addressed at AAA Headquarters, Buhl Planetarium, Pittsburgh 12, Pa.

P. NASH ANDERSON, chairman
Middle East Region
Astronomical League

MADISON LEAGUE CONVENTION

Bulletin No. 1 of the Astronomical League's general convention at Madison, Wis., July 3-5, 1954, has been issued. It contains preliminary information and a printed folder describing astronomical attractions and the University of Wisconsin campus. The convention will be conducted by the North Central region and the Madison Astronomical Society.

The Kronshage unit of the university dormitories has been turned over to conventionites. The first 150 persons who deposit $4.00 toward room and board at the rate of $5.50 a day per person can be accommodated there. If cancelation notice is received before June 20th, the $4.00 will be refunded. Hotels and motels are available also, and these will be listed in a later bulletin.

The convention registration fee will be $1.50 per person if paid prior to May 1st, thereafter $2.00. The fee and the deposit for dormitory accommodations should be sent to Mrs. Harold B. Porterfield, registration committee chairman, 1001 University Bay Dr., Madison 5, Wis.

Space will be provided for both commercial and amateur astronomical exhibits. Those interested in exhibiting should write Ralph Buckstaff, 1039 N. Main St., Oshkosh, Wis., or Max Lindemann, 4154 Nakoma Rd., Madison 5, Wis.

For information on the trip from Milwaukee to the June 30th eclipse, returning to the convention at Madison, readers should contact Roy L. Dodd, 7918 Milwaukee Ave., Wauwatosa 13, Wis.

THIS MONTH'S MEETINGS

Buffalo, N. Y: Buffalo Astronomical Association, 7:30 p.m., Museum of Science. March 3, Dr. E. T. Welmers, Bell Aircraft Corp., "Speed."

Cambridge, Mass.: Bond Astronomical Club, 8 p.m., Harvard Observatory. March 4, John Patterson, Boston Museum of Science, "Man Copies the Heavens."

Chicago, Ill.: Burnham Astronomical Society, 3:30 p.m., Adler Planetarium. March 14, Dr. C. C. Wylie, University of Iowa, "Meteors."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. March 12, Dr. I. M. Levitt, Fels Planetarium, "People and the Stars."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Dallas Power and Light Co. auditorium. March 22, E. M. Brewer and Floyd L. Shirey, "Making Your Own Telescope."

Geneva, Ill.: Fox Valley Astronomical Society, 8 p.m., City Hall. March 9, Dr. Gilbert O. Raasch, Illinois State Geological Survey, "Mountain Heights and Ocean Depths."

Lake Charles, La.: Lake Charles Amateur Astronomers Club, 7:30 p.m., McNeese State College. March 10, W. F. Duncan, "Nebulae and Galaxies."

Lansing, Mich.: Lansing Amateur Astronomers, 8 p.m., No. 8 Fire Station. March 18, Dr. Harry Bendler, Michigan State College, "Astrophysics."

Lorain, Ohio: Black River Astronomical Society, 8 p.m., Spang Bldg. March 3, W. L. Sipple, "Celestial Sightseeing."

Minneapolis, Minn.: Minneapolis Astronomy Club, 7:30 p.m., Public Library. March 3, Dr. Mark Graubard, "Astronomy—an Ancient Science, Ancient Instruments."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. March 3, Samuel C. Silver, "Astronomy in Surveying and Mapping."

Teaneck, N. J.: Bergen County Astronomical Society, 8:30 p.m., Observatory, 107 Cranford Pl. March 10, Capt. C. V. Lee, "Western Observatories and Their Work."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Dept. auditorium. March 6, Dr. James C. Bartlett, Jr., American International Academy, Inc., "The Jovian Version of Sunspots."

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BOOKS AND THE SKY

A GUIDE TO THE MOON

Patrick Moore. W. W. Norton and Co., Inc., New York, 1953. 255 pages. $3.95.

IN THIS BOOK, Patrick Moore presents one of the best-rounded pictures of the earth's satellite published in this century. Combining a wealth of fact with theory, it is lucidly written in "popular" style, but it will be a welcome addition to the library of the more serious student of the moon as well as a valuable help to the beginner.

The book's lively account of the moon as the probable target of man's first venture into space, together with its estimate of the conditions these voyagers will encounter, is appropriate to a space-minded age, and doubtless will win many readers with only a general interest in astronomy.

Moore writes with authority rare among recent authors of lunar studies. He has devoted years to physical observation of the moon's surface. He is a council member of the British Astronomical Association and secretary of its lunar section, a fellow of the Royal Astronomical Society, and a member of the council of the British Interplanetary Society. The book includes a foreword by H. Percy Wilkins commending it as "accurate, factual, and informative."

In its 17 chapters and three appendices, **A Guide to the Moon** considers our queen of the night from many viewpoints. The author orients his subject with a description of the place of the moon in the universe, and discusses theories of the origin of the earth-moon system. Lunar phases and librations are clearly and simply explained. Highlights of the history of lunar observation and the growth of knowledge of the earth's companion are presented. Two chapters describe the moon's surface and prepare the reader for an imaginary tour of lunar scenes, such as might be encountered by the first travelers landing their rocket in the great Ocean of Storms near the crater Herodotus.

Moore plunges with resolution into controversial subjects, such as the origin of lunar formations, possible changes on the lunar surface, and the possibility of life on the moon. Concerning the last of these, he writes, "On the whole moon there is no living thing, apart perhaps from a few scattered patches of lichen or moss-type vegetation on the floors of some of the craters."

As have others before him, the author believes there is good evidence for the existence of an extremely rare lunar atmosphere, perhaps with a surface density of 1/10,000 or less that at the surface of the earth. Such a density, he points out, would largely protect the moon's surface from meteoric impact, for the actual density at an altitude of 50 miles would be equal to that at the same height above the earth. On the moon, in such a case, the density at higher levels would be greater than that of the terrestrial atmosphere. Thus, ordinary meteors (which generally appear about 80 miles above the earth's surface and burn out at about 50 miles) would be as effectively shielded from the moon as they are from the earth. Moore reiterates the need for organized amateur study of lunar meteor trails and impact flares as likely means of learning more about a possible lunar atmosphere.

The surface of the moon, he thinks, was largely molded by volcanic and internal igneous activity, with meteoric impact relegated to a minor role in producing smaller craters and craterlets. Admittedly, he writes, "this picture of the surface molding leaves much to be desired," but it does account for many of the observed facts, "which neither the impact nor the various tidal theories can do."

More than a century ago professional astronomers, on the basis of evidence then at hand and the observational equipment of the time, concluded that the moon is a dead, airless, and changeless world. They saw little purpose in continuing observation, and this has, in the main, become the traditional view of the professional. As a result, selenology has developed largely as the work of observers rising from the ranks of the amateurs. Nonetheless, the observations of hundreds of students of the moon have been preserved in drawings, maps, and photographs made during the past 150 years.

Moore believes the evidence of these drawings and maps is conclusive that changes are taking place in the features of the lunar surface. He cites particularly the case of the formation Linné, which was shown in drawings made prior to 1844 as a well-defined and easily observable crater, but which now is obscure and difficult. He notes that other crater formations mapped by early reliable observers are not now to be found, while present observers detect formations that are unaccountably missing from older maps. He concludes that a change in Linné is established and that others are possible, but that alterations are rare and major upheavals definitely belong to the past. Accounts of mists and strange obscu-

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rations temporarily hiding lunar features open the door to a fascinating observational field.

A chapter is devoted to "The Other Side of the Moon," with some well-founded guesses as to the probable appearance of a hemisphere which will be discovered by the first space travelers, and the suggestion that much can be learned before that time by a systematic mapping of bright rays which appear to center at points on the hidden surface.

The mechanics of eclipses of the moon are considered. The possibilities are discussed of observing lunar phenomena arising from sudden temperature changes, and of gaining information from occultations and lunar meteor trails during eclipses.

Finally, the author reviews problems of rocket travel to the moon and establishment of a permanent base there.

The appendices give information on the technique of lunar observing, moon literature and maps, and brief descriptions of many lunar features. End papers present a simple outline map showing 212 named formations, and a key is provided to aid in locating each of these. The book is adequately illustrated with drawings and photographs.

While all observers will not agree with all of the author's conclusions, it is apparent that he has tried to derive them from the evidence rather than picking and choosing facts to support a theory. The book brings lunar observation up to date, and provides a valuable summary of earlier works that are now almost entirely out of print.

JACKSON T. CARLE
Association of Lunar and
Planetary Observers

A BIBLIOGRAPHY ON METEORITES

Harrison Brown, editor. University of Chicago Press, Chicago, 1953. 686 pages. $10.00.

A Bibliography on Meteorites is a key to the literature of research on meteorites for the years 1491 through 1950. In this stupendous and valuable undertaking, Dr. Brown has had the assistance of associate editors Gunnar Kullerud and Walter Nichiporuk.

Under some 8,600 major entries approximately 25,000 separate references are found. They have been compiled from 1,086 journals, magazines, and newspapers, and 840 books, monographs, catalogues, and pieces of correspondence. Original research items are listed according to the year of their publication, and within each year alphabetically by author. Abstracts and reviews of a paper are listed together with the major reference, but without mention of the reviewer's name. On the average there are two abstracts or reviews corresponding to each of the primary articles cited. Following the bibliography a cross-reference index according to author is given. At the end of the volume, all of the publications searched for references are listed.

If either the author of a particular article or the approximate date of a meteoritic event is known, the book readily enables one to locate the desired reference. On the other hand, for assembling the literature on some particular subtopic in the study of meteorites (for instance, achondrites, the Goose Lake meteorite, tektites), this particular volume will not be too easily helpful. However, this is but the first of three contemplated volumes. It is to be followed by two to be entitled, "Meteorites and Their Properties," of which the first will contain alphabetical, chronological, and geographical indexes of all meteorites and descriptions of stony and stony-iron meteorites. The final volume will include descriptions of the iron meteorites, chemical analyses, a directory to meteorite collections, and a general subject index on meteoritics and related topics. The three volumes, which will comprise An International Catalogue

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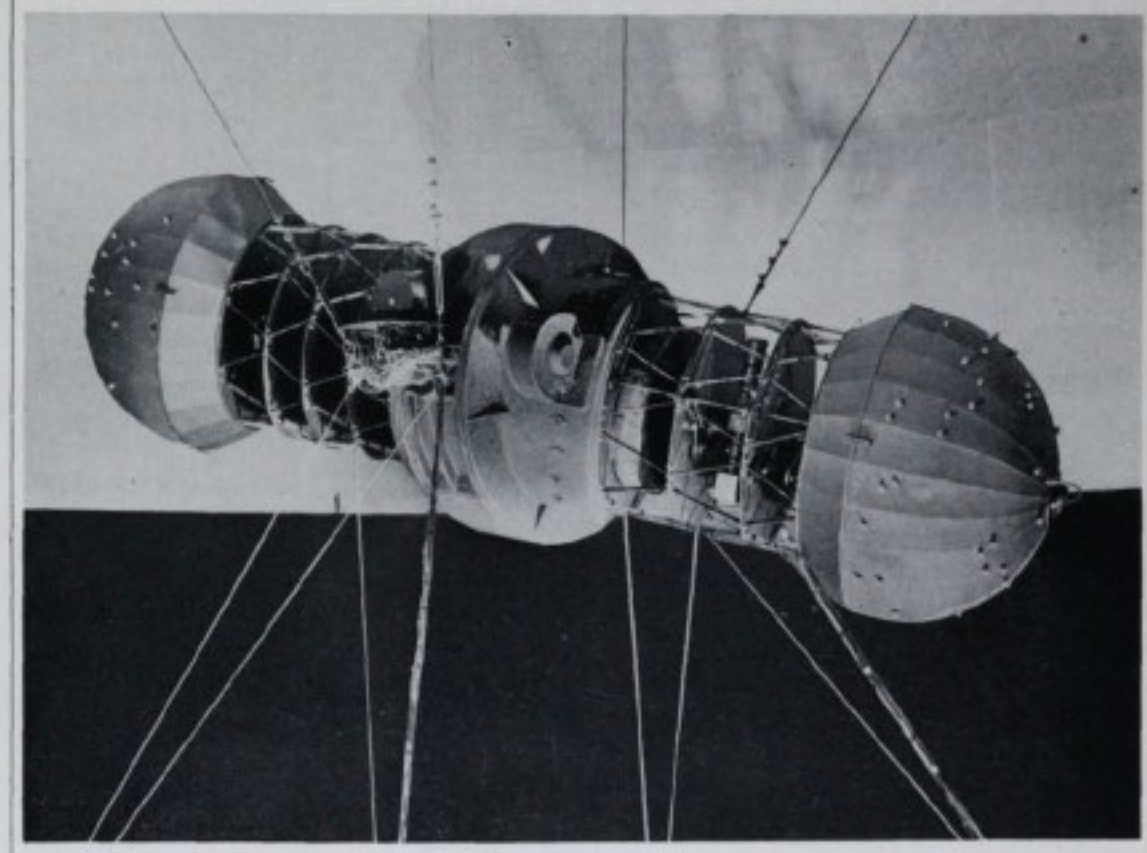

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of Meteorites, should contain all the necessary cross-reference material in the literature of this subject.

While the publishers on their jacket for the present work advertise that it is "truly complete," the editors themselves do not make this claim. In the introduction they state, "The Editors recognize that the bibliography as here presented is by no means complete. A number of references have been located too late for inclusion in the main body of this volume. As time goes on, these additional references will be accumulated and included as a supplement to the second volume."

As the primary listing of the references is chronological, a quick inspection indicates to some extent the growth of scientific interest in meteorites over a period in excess of 450 years. Counting pages by half-century intervals, I arrive at the following tabulation:

Period	Pages of references
1500-1750	1 per half century
1750-1800	5
1800-1850	80
1850-1900	220
1900-1950	260

The upsurge after 1800 may in part have been induced by the spectacular shower of Leonids in 1799, although at that time the relationship between meteors and meteorites was not at all generally admitted. The fall of stones at l'Aigle, France, in 1803, however, was followed by a marked increase in publications for that year; compare the number of major references listed at this time: 1800, five references; 1801, nine; 1802, 23; 1803, 56; 1804, 32; 1805, 20; 1806, 28. World events also have had their influence, as from 1942 to 1946, when the number of references averages about half of those for adjacent prewar and postwar years.

Astronomers and meteoriticists will applaud the publication of **A Bibliography on Meteorites,** and await the completion of the two promised volumes.

DORRIT HOFFLEIT
Harvard Observatory

Sky Publications

MAKING YOUR OWN TELESCOPE. by Allyn J. Thompson — This book gives complete instructions on how to make a 6-inch reflecting telescope, including the mirror and cell, tube, equatorial mounting, and tripod, with discussion of eyepieces, setting circles, and suggestions for a second telescope **$4.00**

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Sky Publishing Corporation Harvard College Observatory Cambridge 38, Massachusetts

NEW BOOKS RECEIVED

SPACE TRAVEL, *Kenneth W. Gatland* and *Anthony M. Kunesch*, 1953, *Philosophical Library*, 205 pages, $4.75.

Mr. Gatland is a British aircraft designer, and the practical and factual viewpoint of the book reflects this engineering background. There is a detailed summary of present-day accomplishments and problems in rocketry, and an appraisal of possible future developments.

THE MOON, *George Gamow*, 1953, *Schuman*, 118 pages, $2.50.

Dr. Gamow has written this book for Schuman's "Man and His World" series, for junior and senior high school science use. There are brief discussions of phases and motions of the moon, the tides, the lunar surface, and travel to the moon.

HIGH ALTITUDE ROCKET RESEARCH, *Homer E. Newell, Jr.*, 1953, *Academic Press*, 298 pages, $7.50.

Dr. Newell is head of the Rocket-Sonde Research Branch of the Naval Research Laboratory in Washington, and so is unusually qualified to write this technical book on the scientific use of rockets. The topics considered are the construction and performance of high-altitude rockets used for research, instrumentation of rockets and the recovery of data, and the information obtained to date by rocket techniques on physical conditions in the upper atmosphere, solar radiation, the ionosphere, terrestrial magnetism, and cosmic rays. There are extensive summaries of experimental data, and full bibliographies of scientific papers.

SIGHT REDUCTION TABLES FOR AIR NAVIGATION, Vol. 3, Latitudes 40°-89°, Declinations 0°-29°, *H. M. Nautical Almanac Office*, 1953, *H. M. Stationery Office*, York House, Kingsway, London W.C.2, 338 pages, £1 1s.

Primarily intended for the air navigator, this volume will have many uses for the astronomer who has to deal with the conversion of co-ordinates. The principal table allows one to read directly the altitude (to one minute of arc) and the azimuth (to the nearest degree) of a star whose hour angle and declination are known.

The material is a British reprint of part of the U. S. Navy Hydrographic Office *Publication H. O. 249*. The computations were made jointly by the Hydrographic Office and the Nautical Almanac Office. Vol. 1 of this series, composed of tables for six selected stars, was noted in the March, 1953, issue.

THE SUN, *Gerard P. Kuiper*, editor, 1953, *University of Chicago Press*, 745 pages, $12.50.

All aspects of contemporary solar research are analyzed in this first installment of a four-volume series on the solar system. The score of contributors includes Bengt Stroemgren on the sun as a star, M. Minnaert on the photosphere, H. C. van de Hulst on the chromosphere and corona, K. O. Kiepenheuer on solar activity, and J. L. Pawsey and S. F. Smerd on solar radio emission. The work is designed to be both a reference handbook for the specialist and a volume understandable to anyone versed in the physical sciences.

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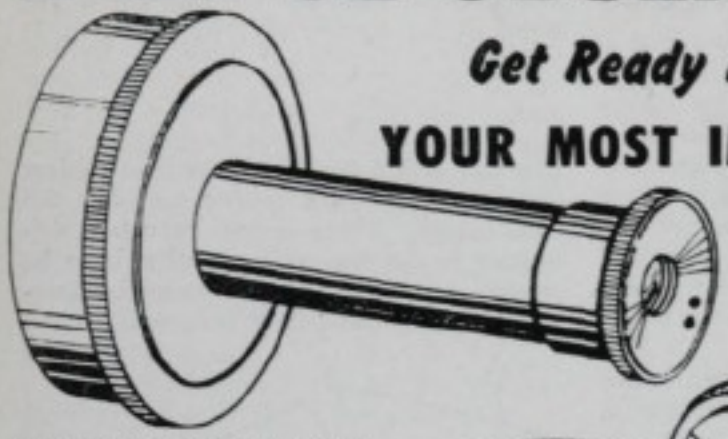

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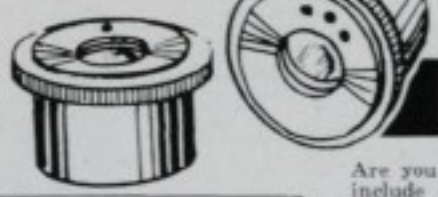

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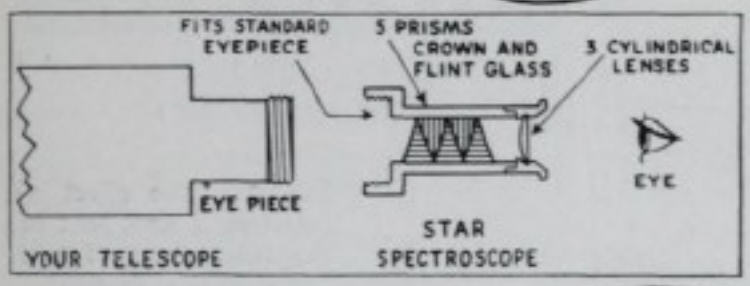

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NOTES ON BASIC OPTICS — VI

F. Pupils and Aperture Stops (Cont.)

Suppose for the second example that a telescope of considerable length is required, say, a submarine periscope. Trying to achieve this by an ordinary erecting system like that in Fig. 16 would give the situation shown in Fig. 20. The aperture stop would be at **A**, between the erectors, as is customary in this design—the symmetrical system. But the erector lenses would have to be made huge because of the great over-all length required.

Instead, we take two instruments like Fig. 16 and, removing the eyepiece of each,

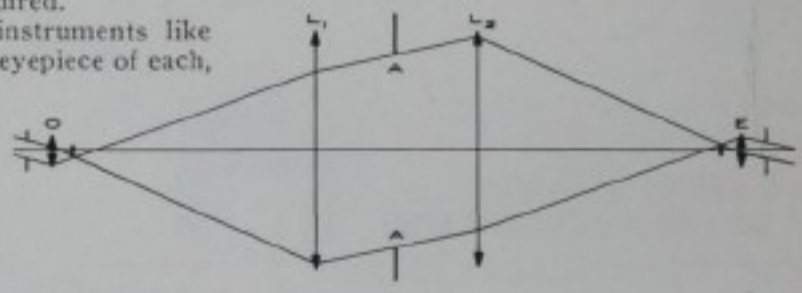

Fig. 20. Illustrating the problem of an erecting system of great length.

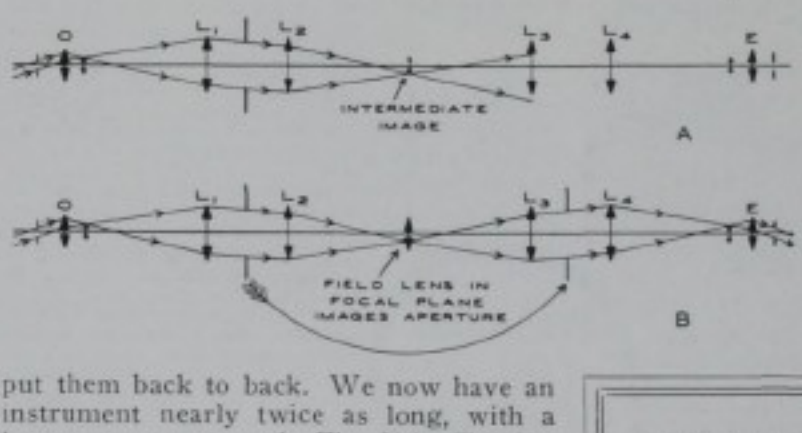

Fig. 21. The effect of inserting a field lens in the focal plane of two symmetrical systems.

put them back to back. We now have an instrument nearly twice as long, with a lens arrangement as in Fig. 21A. Tracing the light through this system, however, we uncover a serious defect, for light is lost at the second erector system.

This situation can be cured very nicely by introducing a positive field lens at the intermediate image plane (Fig. 21B). Here it has no primary effect on the image-forming system of the telescope, but in the pupil-forming system it images the aperture stop from the center of one erecting system to the other. The focal length of this field lens is easily determined by the requirement of Equation 1, for when d' equals —d, either of these distances is 2f, as stated in July. Therefore, the focal length of the field lens is one fourth of the distance between the aperture stops.

The one remaining problem, the extra image inversion resulting from the double erecting system, is easily corrected, for instance, by using a prism.

These two examples show the great usefulness of field lenses in complex optical systems, by allowing us to change pupil locations and lens sizes.

G. Image Formation by Mirrors

1. **Analogies between Mirrors and Lenses.** The properties of lenses and lens systems described in preceding installments can be applied quite directly to mirrors. Mirrors as well as lenses can be used to form images. A concave mirror acts upon a beam of light in the same way as a positive lens; a convex mirror is equivalent to a negative lens (Fig. 22).

The basic equation for mirrors is the same as for lenses, that is, Equation 1:

$$\frac{1}{d'} - \frac{1}{d} = \frac{1}{f},$$

where **d'** and **d** are the distances of object and image from the mirror, and **f** is the focal length. There is one important difference in the way this equation is to be applied, as a result of the change in direction of light when it is reflected from a

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mirror. While there are several ways this could be allowed for, the preferable method is described here.

When this equation is applied to lenses, the distances are considered positive to the right and negative to the left, as explained on page 191 of the May, 1953, issue. We now change this convention, so that distances measured in the direction of the light are positive, and those measured opposite to the direction of the light are negative. We will also follow the rule that all measurements are from the lens or mirror to the point in question.

In using the basic equation to lay out an optical system, we have to remember that the direction of the light is changed at each mirror surface. A concave mirror has a positive focal length f, and a convex mirror a negative f.

With the convention of signs just described, the basic equation applies to lenses as well as to mirrors. We frequently have to deal with optical systems which contain both lenses and mirrors, and it is useful to have a single equation which is valid for both.

All the rules we have developed for image formation by lenses, for magnification and inversion, and for a pair of thin lenses in series, apply equally to

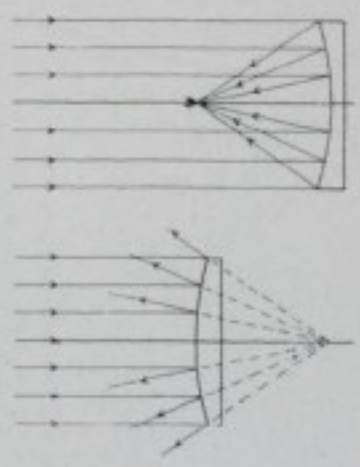

Fig. 22. How convex and concave mirrors focus a beam of light.

optical systems comprised of, or including, mirrors. The formulas given in preceding installments can be used for these new cases, if we adopt the convention on algebraic signs given above.

In November we discussed how various types of optical systems could be simulated by a pair of thin lenses. We shall now examine the corresponding systems which can be obtained with a pair of mirrors, or a mirror-lens combination.

2. **Systems with Two Positive Elements.** A pair of concave mirrors, in view of what has just been said, is evidently equivalent to a pair of positive thin lenses. While such an arrangement is theoretically feasible, it does not represent any standard optical system — even if the separation of the two mirrors were to equal the sum of their focal lengths, which arrangement would constitute a telescope. If, however, we use one mirror and one positive lens, separated by the sum of their focal lengths, we have a Newtonian telescope, as in Fig. 23A. The plane diagonal mirror is added, of course, merely to avoid the observer's head getting in front of the mirror.

It will be recalled that a pair of positive lenses whose separation, t, is greater than the sum of the foci, $f_1 + f_2$, constitutes a compound microscope. The counterpart of this formed by two mirrors is not used, but there are microscopes with positive

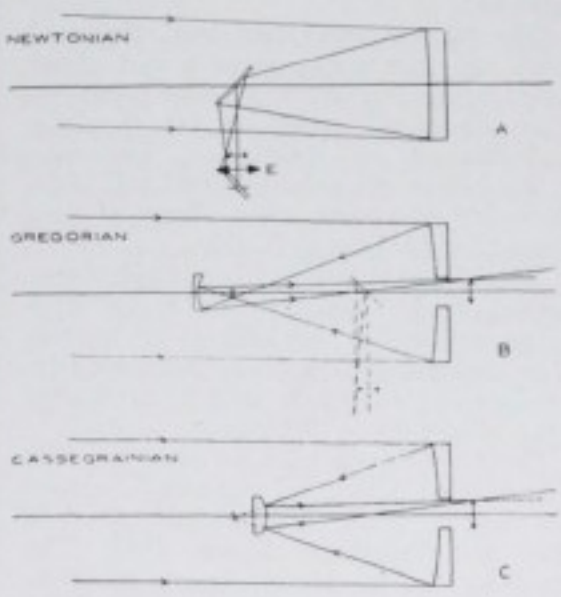

Fig. 23. Three telescope systems.

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There is one mirror system which does not have a lens analogue in practice. This is the case where **t** is slightly greater than $f_1 + f_2$, namely, the Gregorian reflecting telescope, shown in Fig. 23B.

It is customary in Gregorians to cut a central hole in the primary mirror to make the focal plane accessible to an eyepiece. An alternative arrangement, using a diagonal, is indicated in the figure by dotted lines. At present the Gregorian form is seldom used astronomically. It gives an erect image, which is an advantage for terrestrial use, but its excessive field curvature allows only a very small useful field of view.

3. **Systems with a Positive and a Negative Element.** In this case, two mirrors form a Cassegrainian telescope if their spacing, t, is less than the focal length, f_1, of the positive element. This is illustrated in Fig. 23C.

The properties of the Cassegrainian form are exactly the same as those of the telephoto lens, and the equations for the latter, given on page 23 of the November installment, apply to it.

The Cassegrainian is, of course, a reflecting system with a positive focal length, and this type of system is used frequently as the positive element in the reflecting microscopes referred to earlier.

Lastly, the case of two convex mirrors may be dismissed as not used in any representative optical instrument.

(To be continued)

A LONG-FOCUS REFLECTOR

OVER a period of 1½ years, in my spare time, I built the telescope pictured here, a 10-inch f/11 Newtonian. The pyrex mirror was ground and polished on a good old-fashioned metal drum and was pronounced "good results" by an optical company in New York. Rouge was used as the polishing agent, and a record of the knife-edge tests was an aid in figuring.

The mirror cell was made of two triangular pieces of ¼" iron, the points of the two being bent to hold the mirror and to fit into the tube. The mirror is supported at three points and is spring adjusted.

The tube is cork lined and reinforced with ¼" iron rings at each end. Spar varnish weatherproofs all iron surfaces. Two coats of enamel protect the tube and improve its appearance. The tube is secured to the yoke by a ¼" x 4" piece of rolled iron with short pieces of pipe threads welded on each side.

The diagonal support is a rigid three-armed spider which holds a two-inch prism, adjustable and held by set screws. The rack-and-pinion device provides better focusing during the cold winter nights that plague us in Wisconsin.

Good 2 x 6's are used for the mounting framework, which was inspired in part by that of T. R. Cave, Jr., described in **Sky and Telescope,** March, 1951. The double-yoke mounting almost naturally goes with wood construction. A college student's pocketbook does not allow for

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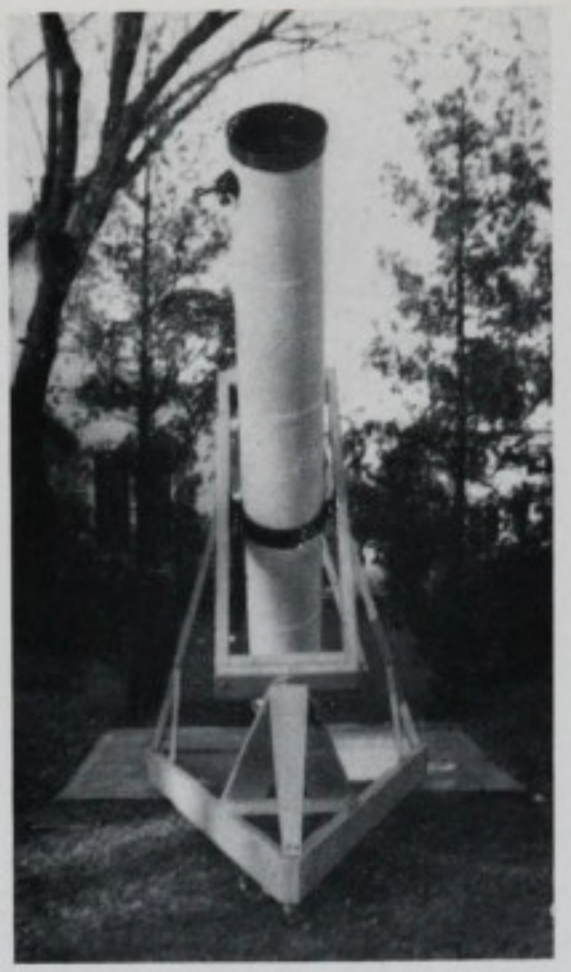

Joseph Raab's 10-inch telescope and its wooden mounting.

much machine work; however, the mounting has proven very strong and rigid. The polar axis runs through two ball bearings and turns very smoothly.

A housing on wheels is in the process of construction, and after that an electric drive will be undertaken.

Regardless of the amount of work put into it, the telescope more than satisfies me in performance. I would be glad to see other amateurs when they are in Oshkosh, because there are few of us here.

JOSEPH A. RAAB, JR.
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Dip the brass piece in the solution and then hold it in a Bunsen flame (or gas stove flame), with the air turned on full to keep the flame oxidizing. The copper coating should dry, turn green, and finally black. Immerse the brass in the solution a second time while it is still very hot and then dry it in the flame; repeat this procedure at least four times for a good coat. After the last application, cool the brass under a water tap and dry it.

Hot nitric acid is dangerous, and precautions should be taken against getting it on the skin.

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OBSERVER'S PAGE

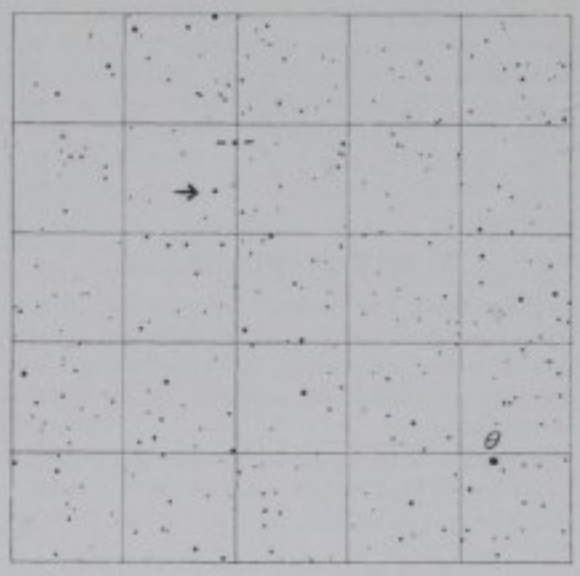
Universal time is used unless otherwise noted.

An Occultation of a Star by Pallas

THE MINOR PLANET Pallas will occult the star BD +5°2171 on April 6-7, 1954. The "shadow" of the occultation is very favorably situated; it is expected to pass across Mexico, the United States, and Canada at altitudes varying from about 75° to 40°. As many observations as possible, by both professional and amateur astronomers, are desired, mainly in order to derive a value of the planet's diameter; a detailed prediction is accordingly given below.

An occultation by a minor planet is quite a rare event. Making certain simplifying assumptions, the probability has been calculated of Pallas occulting stars of various magnitudes. The results show that the average number of occultations per century for limiting visual magnitude 6 is 1.2; magnitude 7, 3.5; magnitude 8, 9.9; and magnitude 9, 28.

The chance of an occultation occurring with a large portion of its track covering an inhabited area of the earth at a reasonable altitude is still smaller. In addition, some occultations of faint stars will be unobservable if the minor planet is bright, as the decrease in combined magnitude at such an occultation would be too small to be registered, compared with variations due to atmospheric disturbances. Hence it is hoped that every possible observation will be made of this very rare phenomenon, which as far as is known has never previously been observed. (On May 29, 1952, Juno must have occulted a star; the minor planet was seen north of the star by observers in South Africa and south of it from France.)



The arrow points to the star BD +5°2171, which Pallas will occult about 8:25 p.m. Central standard time, April 6th. The dashes bracket BD +5°2169. North is at the top of the chart, which shows stars to about magnitude 10; the squares have 1° sides. The bright star in the lower right corner is Theta Hydrae, magnitude 3.8, whose 1950 position is $9^h\ 11^m.8$, +2° 32′. The brighter stars on this chart may be identified along the path of Pallas published on page 64 of the December, 1953, issue. Pallas will be in this field more than a week before the occultation. From the "Bonner Durchmusterung" atlas.

The phenomenon may be recorded either photoelectrically or visually. The magnitude of Pallas will be 7.1 and that of the star is 8.0. When the two objects are very close together, their combined magnitude will thus be 6.7, and if an occultation occurs this will fall to 7.1 at disappearance and, of course, return to 6.7 at reappearance.

The visual observer located within the region of visibility of the occultation will witness the following phenomena. Twenty minutes before the occultation Pallas and the star will appear as a double star with a separation of about 17", Pallas having so small a disk that it will look stellar. This "double star" will gradually close in, but the observer must not mistake the apparent merging together of the images for an actual occultation. With a small telescope the two images will be unresolved for several minutes before and after the occultation. Continuing to watch the merged image, the observer will see it suddenly become fainter by 0.4 magnitude as the asteroid passes in front of the star, and this is the first time to be recorded. Some seconds later (at most 32), the combined image will suddenly brighten by 0.4 magnitude, as the star is uncovered, and this is also to be timed.

To detect these brightness changes visually, use a low-power eyepiece so that BD +5°2169, magnitude 6.8, can serve as a comparison star. It is 30′ distant, in position angle 335° referred to the occulted star (north-northwest of it). The observer should fix his attention on a point between the two images to be compared.

Times should be recorded to an accuracy of at least one second. Clocks ought to be checked by radio time signals before and after the occultation. If this is not possible, observations of **the duration** of the occultation, preferably with stop watches, will be of great value. [Reference should be made to **Sky and Telescope,** October, 1953, page 317, for instructions on timing the transit of Mercury, much of which is pertinent here, and to the article in the January issue, page 75, for reports on transit timing methods used by various observers.—ED.]

Dr. A. Hunter, at the Royal Observatory, Greenwich, has kindly carried out some experiments to determine whether such a visual observation is possible. An observer at the eyepiece of the guiding telescope of the astrographic refractor was able to record instantly the time when an opaque disk of suitable size was placed over the objective, thereby dimming the star in the field by 0.4 magnitude. Visual observers are advised to perform a similar experiment for themselves as practice, covering one third of the area of the objective lens or mirror.

The ephemerides of the minor planets in the **British Nautical Almanac** and the **American Ephemeris,** although gravitationally consistent to high accuracy, give true positions only to within a few seconds

TABLE I

Lat.	Longitude west. limit	Longitude cent. line	Longitude east. limit	Time of disappearance (central line)	Altitude on central line	Corr. to Long.	Corr. to Time
°	°	°	°	h m	°	°	m
+20	+101.0	+98.6	+96.3	2 23.7	73	+10	−0.4
25	99.5	97.0	94.6	24.4	69	11	4
30	97.9	95.3	92.8	25.0	65	11	5
35	96.3	93.6	90.9	25.5	60	12	5
40	94.7	91.7	88.8	26.1	55	13	5
45	92.8	89.6	86.6	26.6	50	14	5
50	90.7	87.4	84.1	27.1	45	16	5
+55	+ 88.7	+84.7	+80.7	2 27.7	40	+18	−0.6

TABLE II

0ʰUT April	Pallas—Star R. A.	Dec.	A	B	C	D	H
	m s	′ ″	m	m	″	″	″
1	−2 34.62	−123 03.8	−0.38	−1.07	−1.45	+0.23	6.16
2	2 13.58	101 56.1	42	07	45	25	6.12
3	1 50.83	81 10.4	46	08	44	28	6.08
4	1 26.39	60 47.0	51	08	43	30	6.03
5	1 00.27	40 46.2	55	09	42	32	5.99
6	0 32.50	21 08.0	60	09	40	34	5.95
7	−0 03.08	− 1 52.8	−0.64	−1.09	−1.39	+0.37	5.90

of arc. This accuracy is inadequate to predict the track of the occultation over the surface of the earth at all precisely. However, the path of the shadow in Table I and shown on the accompanying map has been based rigorously on the ephemeris, using one more decimal than those published; the position of the star has been taken from the Yale zone catalogue. The following elements result:

Time of conjunction	2:26:33 UT
Right ascension	9ʰ 22ᵐ 03ˢ.361
Declination of Pallas	+4° 57′ 38″.22
Declination of star	+4° 57′ 34″.68
Motion per minute	0″.853
Position angle of motion	21°.69
Horizontal parallax of Pallas	5″.90
Semidiameter of Pallas	0″.23
Maximum duration of occultation	0ᵐ.54

The semidiameter of Pallas, the maximum duration, and the western and eastern limits of the track are based on an assumed diameter for the asteroid of 306 miles; although this value rests on the best available determination, it is subject to considerable uncertainty.

In Table I, the last column lists corrections applicable to the central line for an alteration of +1.0 second of arc in the geocentric orbital latitude, **b**. If Pallas is 1.0 second north of its predicted position, the central line will be shifted to the western boundary of the shaded area on the map; if it is 1.0 second too far south, the central line will be shifted to the eastern boundary of the shaded area.

The position of the track of the occultation is very sensitive to the relative positions of the planet and the star, and no significant improvement to the ephemeris positions can be made until the star and Pallas are close enough for them to be photographed on the same plate. Some observers may be able to obtain such observations photographically several days prior to the occultation and thereby apply corrections to the tabulated track. Hence, an ephemeris of the geocentric differences in right ascension and declination is given in Table II for six days before the occultation, together with the horizontal parallax of the planet, **H**. The column headed R.A. is the right ascension of Pallas minus the right ascension of the star; Dec. is the declination of Pallas minus the declination of the star.

The effect of small differences ($\Delta\alpha$ and $\Delta\delta$) between the observed and predicted values of these quantities may be expressed as changes in the position of the shadow in directions parallel and perpendicular to the track. The former will only sensibly

The "shadow" of Pallas will sweep northward. The times on the central line refer to disappearance of the star behind Pallas; reappearance on the central line will occur 0.54 minute later. Observers who do not wish to time the occultation may enjoy watching as the minor planet and the star appear to blend as one; to those who are in the actual path of the occultation, there will also be a change in brightness for a fraction of a minute.

UNITRON

The UNITRON 4″ Photographic Equatorial "surpasses the limits of an amateur-type instrument," says owner Max Koeppel, of Cincinnati, Ohio.

Mr. Koeppel's son Gerhard at the controls of the 4″
Photo by Max Koeppel

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change the time of the occultation, while the latter will, for a given latitude, cause a change in longitude as well as in the time.

The corrections to be applied to the relative ephemeris are:

$$\Delta t = A\,\Delta\alpha + B\,\Delta\delta,$$
$$\Delta b = C\,\Delta\alpha + D\,\Delta\delta,$$

where $\Delta\alpha$ is measured in units of 0.1 second of time and $\Delta\delta$ in seconds of arc, and Δt is the change of time of occultation in minutes. The correction in Table I for Δb is only given to the nearest degree of longitude, as this corresponds to an accuracy of Δb of about 0".1. The coefficients **A**, **B**, **C**, and **D** are also given in Table II.

It is hoped that final values of these corrections can be made available to observers; we are proposing to make observations at Herstmonceux and cable or telephone corrections to the U. S. Naval Observatory. That observatory has agreed to send collect telegrams containing any last-minute information on the day before the occultation. Observers desiring this service should notify the U. S. Naval Observatory, Washington 25, D. C., attention of G. M. Clemence.

Amateur astronomers are capable of making an important contribution to this project, and therefore it is suggested that all observers in North America situated east of about 110° west longitude attempt the observation.

The author would be grateful to receive all observations in full, even negative ones, at the address below. Reports from visual observers should include information on what timepiece was used and how its correction was determined; the aperture and magnification of the telescope; and the geographical location of the observer, in latitude and longitude to the nearest minute of arc. Observers with photoelectric equipment should give similar pertinent information.

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JANUARY LUNAR ECLIPSE

A FEW EARLY reports, from observers widely scattered geographically, indicate that the weather for the total eclipse of the moon on the evening of January 18th was far from good.

Dallas, Tex.: E. M. Brewer writes that it was foggy all day, and nothing was seen until about a half hour after totality ended.

Portsmouth, Va.: G. R. Staples had overcast before totality and broken clouds during it; it was cloudy again by 10:35 p.m. EST.

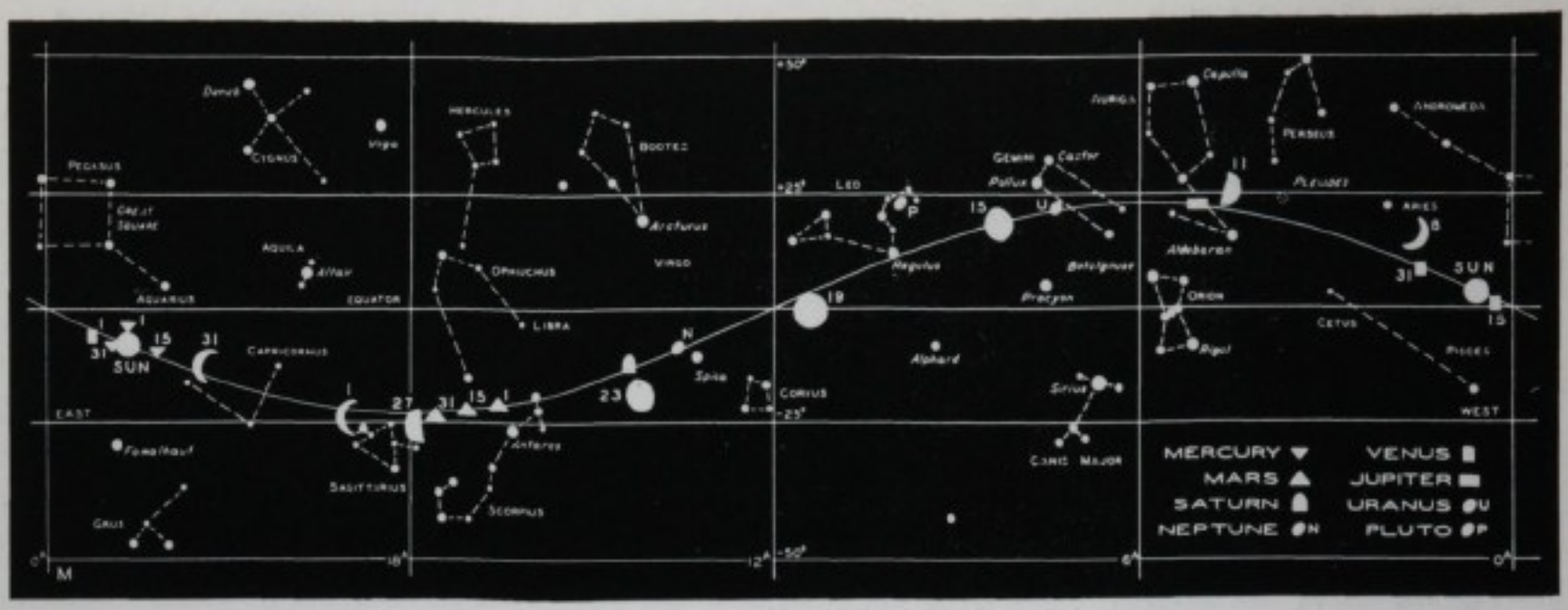
Oceanside, N. Y.: The first part of the eclipse was seen by Peter A. Leavens, on Long Island, but a thin cloud layer largely obscured most of totality and the waning phases. Noticeable only was the comparatively brighter illumination of the moon's southern limb as it moved through the edge of the umbra.

San Juan, P. R.: Jaime Annexy observed with continuous interruptions by low clouds, and the newspaper **El Mundo** published a series of photographs that showed the southern edge of the moon very bright even while it was in the umbra.

Guatemala, C. A.: Photographs of the eclipse, showing detail in the umbra during the partial phases, were taken by Raul Gonzalez, and transmitted by P. Perez Valenzuela.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury enters the morning sky on March 1st, passing inferior conjunction with the sun. Greatest elongation is attained by March 28th, 27° 49′ west of the sun. This will be a poor apparition for northern observers, as Mercury rises only one hour before the sun, shining at magnitude +0.5. For observers in the tropics or southern latitudes, the planet will rise two hours before the sun.

Venus may first be viewed in the evening sky without optical aid about mid-March. Setting some 50 minutes after the sun, the planet appears at magnitude −3.4. The disk is 98% illuminated, but because Venus is on the far side of the sun, its apparent diameter on the 15th is only 10″.

Earth will arrive at heliocentric longitude 180° on March 21st, at 3:54 Universal time. Spring commences in the Northern Hemisphere and autumn in the Southern, with days and nights approximately equal over the earth.

Mars attains western quadrature with the sun on March 2nd, rising shortly after 1 a.m. local time. The ruddy planet will be traveling eastward in southern Ophiuchus all month. It brightens from magnitude +0.8 to +0.1 during March. Telescopically, Mars presents a gibbous disk, 8″.4 in diameter on the 15th.

Jupiter, located high on the meridian at sunset, passes eastern quadrature with the sun on March 8th. The giant planet is now moving in direct motion in eastern Taurus, at magnitude −1.8. The Jovian disk is 38″ in equatorial diameter on the 15th.

Saturn rises 3½ hours after sunset, appearing as a yellowish star of +0.6 magnitude. The planet is in retrograde motion in western Libra, and will reach opposition next month. The ring system, a favorite telescopic object, presents its northern face inclined 18°.6 to our view, with a major diameter of 41″.3, in mid-March.

Uranus, visible with the slightest optical aid, until 2 a.m. local time, may be viewed about 1½° east and ½° north of Delta Geminorum. Eastward motion resumes March 27th, though little apparent motion can be noticed all month.

Neptune will rise 1½ hours after sunset in late March. It is of the 8th magnitude. See the charts in the February issue for the paths of Uranus and Neptune.

E. O.

OCCULTATION PREDICTIONS

March 9-10 **23 Tauri** 4.2, 3:43.6 +23-48.4, 5, Im: **H** 5:36.0 −1.1 +0.7 41.

March 24-25 **Sigma Scorpii** 3.1, 16:18.4 −25-29.0, 20, Em: **A** 6:31.7 −0.6 −0.3 323; **B** 6:30.1 −0.4 −0.4 329; **C** 6:28.8 −0.9 +0.1 308.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the **British Nautical Almanac** are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
			I	+123°.1,	+49°.5

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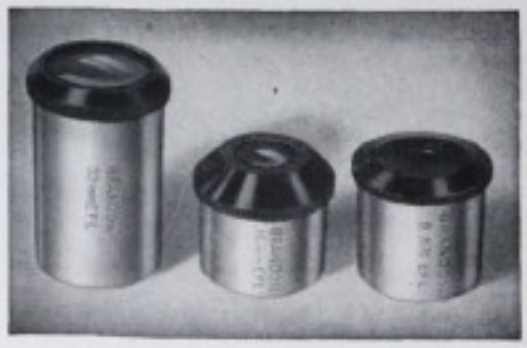

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DEEP-SKY WONDERS

WHILE THERE are a few faint external galaxies scattered through western Hydra, the great richness of the Coma-Virgo fields begins to show in Leo, where the typical "bunching" already is obvious. We take one of these groups this time—the spirals around M65 and M66 in Leo.

In brightness, these galaxies range from binocular subjects to faint blobs at the limit of a large amateur reflector. M65, NGC 3623, is at $11^h\ 16^m.3$, $+13°\ 23'$. It is an Sb spiral, of photographic magnitude 10.5, and 8′ by 2′ in extent. Although it is in the Messier catalogue (see page 158 of this issue), very little is said about M65 in handbooks. It is well worth inspecting, especially with the technique of averted vision, whereby its quite respectable dimensions will become apparent. In the same low-power field lies the companion M66, NGC 3627, $11^h\ 17^m.6$, $+13°\ 17'$, magnitude 9.9, 8′ by 2′.5, also type Sb.

It is interesting to compare these for brightness, to see if the difference of 0.6 magnitude given above varies with the instrument, and whether it is the same for visual observations as for photographic. Generally, the visual magnitudes should be about a magnitude brighter. I shall be interested to know any results of careful comparisons.

In this comparison one might include NGC 3628, almost in the same field. It is at $11^h\ 17^m.7$, $+13°\ 53'$, magnitude 11.3, 12′ by 1′.5, again an Sb, seen nearly on edge. The remaining three galaxies are all faint, objects for fine instruments and excellent nights: NGC 3593, $11^h\ 12^m.0$, $+13°\ 06'$, 12.4, 4′.5 by 1′, Sb; NGC 3596, $11^h\ 12^m.4$, $+15°\ 04'$, 12.2, 4′ by 4′, Sc; NGC 3666, $11^h\ 21^m.9$, $+11°\ 37'$, 12.6, 3′.5 by 0′.7, Sc.

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F. J. Henrich, Long Island, N. Y.
SEE the outside back cover
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SUNSPOT NUMBERS

American sunspot numbers for November are: Nov. 1, 13; 2, 12; 3, 13; 4, 4; 5, 1; 6, 0; 7, 0; 8, 1; 9-19, 0; 20, 1; 21-24, 0; 25, 3; 26, 1; 27, 2; 28, 1; 29, 0; 30, 0. Means for November: 1.7 American.

American and Zurich sunspot numbers for December are (date, American number, Zurich number): December **1-5,** 0, 0; **6,** 4, 0; **7,** 6, 0; **8,** 1, 0; **9-20,** 9, 0; **21,** 1, 0; **22,** 0, 0; **23,** 0, 0; **24,** 3, 8; **25,** 7, 9; **26,** 3, 9; **27,** 1, 9; **28,** 15, 10; **29,** 9, 9; **30,** 0, 0; **31,** 0, 0. Means for December: 1.6 American; 1.7 Zurich.

Daily values of the observed mean relative sunspot numbers are given above. American numbers are computed by D. W. Rosebrugh from AAVSO Solar Division observations; Zurich numbers are from Zurich Observatory and its stations in Locarno and Arosa.

MOON PHASES AND DISTANCE

New moon	March 5,	3:11
First quarter	March 11,	17:51
Full moon	March 19,	12:42
Last quarter	March 27,	16:14
New moon	April 3,	12:25

	March		Distance	Diameter
Perigee	6,	10^h	223,500 mi.	33′ 14″
Apogee	21,	18^h	252,400 mi.	29′ 25″
	April			
Perigee	3,	20^h	221,900 mi.	33′ 28″

VARIABLE STAR MAXIMA

March 6, Chi Cygni, 194632, 5.3; 7, R Normae, 152849, 7.2; 14, R Trianguli, 023133, 6.3; 17, T Centauri, 133633, 6.1; 18, Omicron Ceti, 021403, 3.7; 19, U Herculis, 162119, 7.6; 23, R Geminorum, 070122a, 7.1; 26, U Orionis, 054920a, 6.6; 26, R Corvi, 121418, 7.6; 29, W Lyrae, 181136, 8.0. April 3, W Andromedae, 021143a, 7.5.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (third face if southern), and the predicted magnitude.

PREDICTIONS OF BRIGHT MINOR PLANET POSITIONS

Ceres, 1, 7.1. (Note: A chart of Ceres' path was published in the January issue.) Mar. 9, 13:04.7 +10-47; 19, 12:57.9 +11-46; 29, 12:49.6 +12-35. Apr. 8, 12:41.0 +13-07; 18, 12:33.0 +13-18; 28, 12:26.7 +13-05.

Ausonia, 63, 9.6. Mar. 19, 13:48.3 −17-38; 29, 13:41.6 −17-43. Apr. 8, 13:32.5 −17-32; 18, 13:22.3 −17-06; 28, 13:12.4 −16-27. May 8, 13:04.2 −15-45.

Aurelia, 419, 9.6. Apr. 18, 15:51.8 −20-48; 28, 15:47.9 −20-10. May 8, 15:41.4 −19-19; 18, 15:33.4 −18-21; 28, 15:25.3 −17-22. June 7, 15:18.6 −16-27.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1954.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

A sheet giving bright minor planet positions for 1954 will be mailed on request to the Cincinnati Observatory, Observatory Place, Cincinnati 8, Ohio. Enclose a self-addressed stamped envelope.

MINIMA OF ALGOL

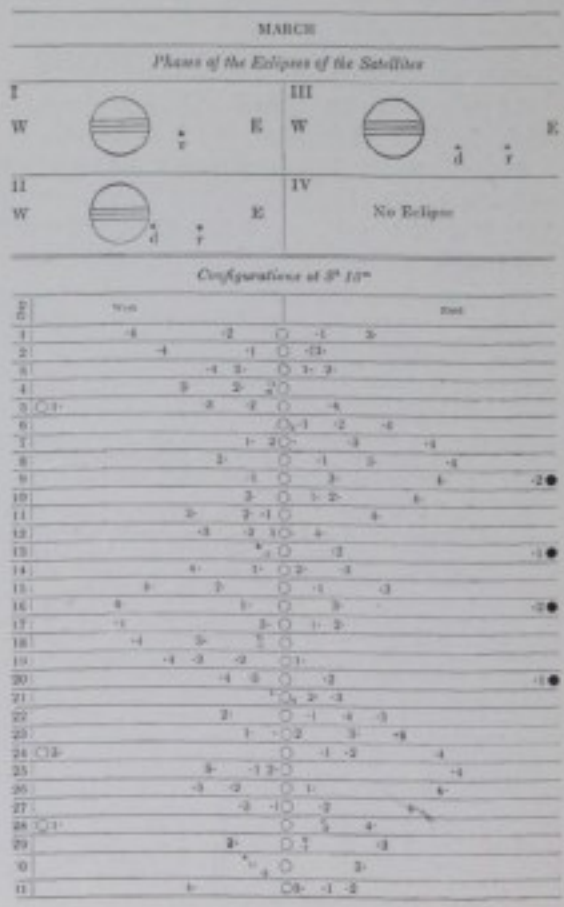
March 1, 12:37; 4, 9:26; 7, 6:16; 10, 3:05; 12, 23:54; 15, 20:43; 18, 17:32; 21, 14:21; 24, 11:10; 27, 8:00; 30, 4:49. April 2, 1:38.

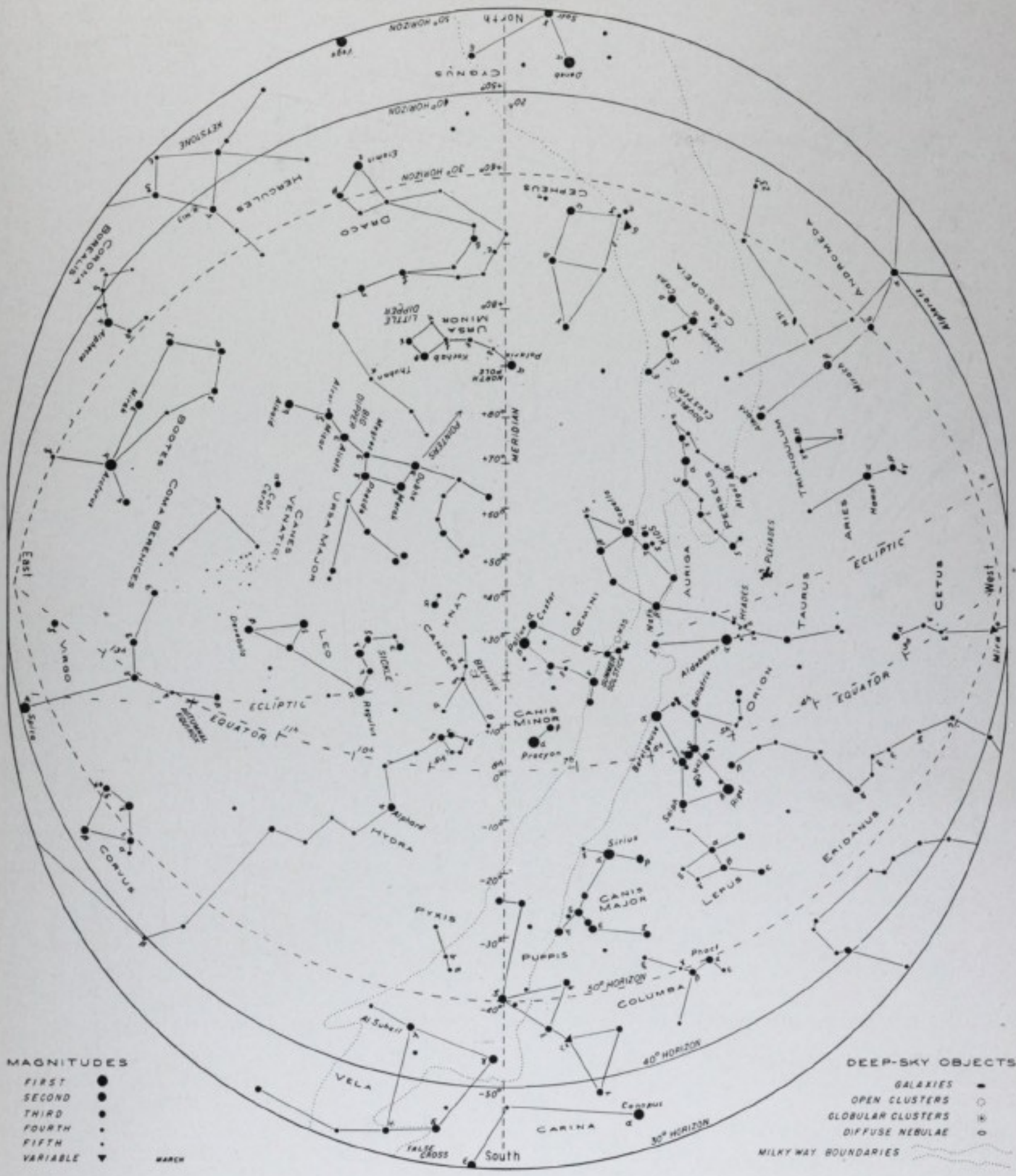
These minima predictions for Algol are based on the formula in the 1953 **International Supplement** of the Cracow Observatory. The times given are geocentric; they can be compared directly with observation.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, **d** is the point of disappearance of the satellite in Jupiter's shadow; **r** is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given; subtract one day from the date when converting to times in the United States. The motion of each satellite is from the dot to the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the **American Ephemeris and Nautical Almanac.**





The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of March, respectively.

STARS FOR MARCH

WITH THE RETURN of warmer evenings in March, constellation study becomes a more comfortable occupation, and spring is a favorable opportunity to become acquainted with the star group of Cancer, the Crab.

High in the southern sky at chart time, Cancer lies between Leo and Gemini. It is the most inconspicuous of the zodiacal constellations, as its four brightest stars are only of the 4th magnitude. For this reason, a clear moonless night and the absence of artificial lights will be helpful in learning this asterism.

The most noteworthy feature of Cancer is the great star cluster, Praesepe or the Beehive, known also as M44. It lies a little south of a line joining Pollux and Regulus, somewhat nearer the former star. To the naked eye it appears as a nebulous object of about the 4th magnitude, looking much like a faint comet in the sky.

Even in ancient times the Beehive was a familiar object. Pliny the Elder, in the 1st century A. D., listed it as a weather omen, holding that the non-visibility of Praesepe in a clear sky presaged a violent storm.

In binoculars, the Beehive is easily resolved into its component stars, and makes a striking spectacle. The cluster contains about 80 stars brighter than magnitude 10, all of which are intrinsically more luminous than the sun; hundreds of still fainter stars have been counted in this group, down to the 18th magnitude.

News and Views of 120th Meeting of AAAS in Boston

Scientific Exhibits Attract Throngs at Mechanics Building; Study New England Economy

...ote by Ed Keller, Globe Staff)
...?—Lt Donald Thomp-
...about the Aerobee re-
...gear for research in
...rt of the Air Force
...A. A. S. meeting.

SCIENTIFIC INVESTIGATION—Katherine Smith of Tufts Medical School bacteriology department takes a look through a Unitron, four-inch photographic equatorial telescope.

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